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REAR-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

OCEAN CURRENTS AND THEIR INFLUENCES.

By A. G. FINDLAY, F.R.G.S.

THE science which treats of the grandest branch of terrestrial physics has no specific name. Whilst every subject relating to the land has an appropriate terminology, those belonging to the movements of the ocean have been so little studied as a whole, that it has not hitherto been thought necessary to exalt it into a separate branch of physical science.

Yet the condition, movements, and influences of four-fifths of the earth's surface have so important a relation to all terrestrial phenomena, that the topic is worthy of the deepest consideration, and most laborious investigation. These enquiries are still almost in their infancy, and what I shall have to say is rather an exposition of our ignorance than an endeavour to construct a perfect system on the basis of our present knowledge.

The waters of the ocean in the northern hemisphere cover, as is well known, an area in proportion to the land as 150 is to 100. In the southern hemisphere this relation is widely different, the proportion of land to water being as 100 to 628. This great distinction is still more remarkable if we take the horizon of London as a division of the sphere. All the land will be in the hemisphere around it, and all the water (except Australia) will be on the opposite half of the globe. Thus, the proportion of land to water on the whole earth is about as 10 to 39; and their distribution has a great influence on our subject.

There is generally much misconception as to the proportionate

magnitude of the ocean and its currents to the earth it envelopes. A familiar example will illustrate this. A well printed book, or atlas, of 1,000 pages, or 500 leaves, will be about 4 inches thick. Therefore, if we suppose the thickness of one such sheet to represent the ordinary depth of the ocean, say two miles, it would require a globe nearly three feet in diameter to be covered with such paper to represent the due proportion between the masses of the earth and ocean. But as all known currents do not extend to one-fourth, and by far the greatest part of them not to one-eighth of the entire depth, it follows that the mass of surface-waters in motion would require a globe of more than 20 feet in diameter to show their proper relation with the sheet of paper.

In approaching the general subject of ocean currents, I would at once separate it into two branches: the first of those surface movements with which we are tolerably intimate; and those more deeply seated motions, which, however certain we may be that they are going on, we can neither properly estimate nor assign definite causes for, in the present state of our knowledge.* But the light begins to glimmer even on this hidden world.

As regards the cause of surface currents, without including minor forces, such as tides, either atmospheric or marine, evaporation or deposition, or the unequal distribution of heat, I think it may be affirmed beyond all question that the great primary agent is the action of those winds, either persistent or transient, which blow over their respective areas.

In the brief space allotted to these remarks, only the movements of the wide ocean, beyond the interfering influences of shoal water, or of the friction of the coasts, which cause reverse currents in every variety, can be considered.

I would briefly allude to the methods by which the direction, velocity, and depths of currents are ascertained. Those to whom the subject is familiar will pardon my thus dwelling on its alphabet, as many may not know how their action, silent and unappreciated, becomes perceptible. The first and principal source of our knowledge is that derived from innumerable ships' log-books and journals. In these, the difference between computed position of the ship, and that obtained from time to time on her voyage by direct astronomical observation, is considered to be due to the action of a current. It may justly be objected to this, that our subject, then, depends on the errors of dead reckoning, and that a current is made the scapegoat for all imperfections and mistakes. And so it is. But in the great mass of figures that have been integrated, it may fairly be presumed that the errors have neutralized each other. It may also be presumed that the older logs have furnished us with much more trustworthy data

* Mr. Wm. Leighton Jordan's work is deserving of attention in relation to this subject. In vol. i. of this, entitled "The Elements,—an investigation of the forces "which determine the position and movements of the ocean and atmosphere," London, 1866,—the Author, by a logical sequence of arguments, accounts for most of the known surface currents and many unknown lower movements, referring the cause to the vis inertiæ of the ocean.

than we could obtain from those of modern ships, into the construction of which so much iron enters, and which, with their much greater length than the older wooden ships, have such a marked effect on the compasses they are steered by.

The next mode of estimating current action is by the drift of floating bodies, and especially of bottles cast overboard for the purpose. These have been largely collected by Captain Becher, R.N.,* and tell a singularly consistent tale, but which certainly involves some amount of fallacy, because being partially above the water, they are acted on by the wind. This has led to much controversy as to their value, which, however, cannot be denied.

The next is the test by temperature; and this ought also to tell us the depth of a current. A current may be readily traced by the thermometer in its progress, and its gain or loss of temperature should be capable of exact measurement, according to those now-well-known laws of absorption and radiation of heat. But, unfortunately, the great mass of figures at our disposal on this head—and the aggregate is really very great—are much impaired in value by the manifestly different conditions under which the observations have been taken.

One point I would deferentially but firmly urge, that all observations for temperature and specific gravity, which are procured for the purposes of comparison, should be taken at a few fathoms below the surface. I feel very confident, from an examination of a large number in many parts of the ocean, that there is a wonderful uniformity in the character and constitution, of temperature and specific gravity, when these are freed from atmospheric interferences.

At small depths the temperature is very simply procured. Not so at greater depths; and I fear that most of the older observations, obtained with so much labour and zeal, are not to be trusted. If they are to be abandoned, we must also throw over the many theories based upon them. It has been recently shown that the bulbs of the thermometers are so much affected by pressure, that a much more complicated system is necessary. Nevertheless, for the purposes of a general view of the ocean, our data are sufficient.

It would be of the greatest advantage to this subject if some uniform system of classifying the observations we at present possess were adopted, because, as they are now used, they can be made to fortify any argument. But as these scattered observations have been taken under every variety of circumstance, it is manifest that their incongruities tend to neutralize their value, however trustworthy they may be in themselves. Comparisons can only be made between observations of similar character. Admiral Sir Edward Belcher has made a large collection of these observations, which are distributed over a wide area of literature, and I trust he will give them to the world in a connected form. Captain Henry Toynbee, too, is doing unbounded service to the cause by the works he has in hand, in collecting and integrating the data collected in the archives of the Meteorological Department.

The American surveyors have used a great variety of thermometers,

* Nautical Magazine, February, 1843.

and up to a certain depth their action is quite trustworthy; but they evidently begin to fail when greater depths are attained, the observations becoming incongruous.

One theory, which was advanced by Sir James Ross from observations commenced in his Antarctic voyage in January, 1843, I think must be abandoned on this account, or at least it must be reserved for further confirmation. It was, that sea water being at its maximum density at a temperature of 39°·5 Fahr., there would be some line when it would be of this temperature from the surface to the bed, and that on the Polar side of this, the water would be colder above this stratum of 39°·5, and on the Equatorial side, it would be warmer; so that under the Equator it would be found only at a depth of 1,200 fathoms.*

The more refined methods used in the late cruizes of H.M.S. "Porcupine," under the guidance of Dr. Carpenter and Dr. Wyville Thompson, will place this matter on a new basis.

The one great principle I would start with, the fundamental axiom of ocean movements, is that there is a continuous inter-circulation of the whole of the surface waters of the ocean—that a particle of water on its surface will visit, in its turn, every portion of the globe. This can be traced. But I would go farther than this, and contend that the whole body of the ocean water is in constant circulation and interchange from the surface to the bed.

I have said that I believe it to be demonstrated that wind is the great originator of surface currents. If the ocean were as free to move as the atmosphere—that is, if the globe were all covered with water—the movements of the ocean would be very simple. There would be a broad belt of water, 3,500 miles wide between the tropics, and acted on by the trade winds flowing to the *westward* all round the globe. On either side of this, between the tropics and the polar regions, there would be two belts of smaller area, impelled by the anti-trades to the *eastward*, and, probably, on the equator there would be a narrow belt of water flowing to the *eastward* also. But as the distribution of land and water is such, that the ocean is separated longitudinally into three great basins, a series of more complicated movements, but each very simple and resembling each other, is found in every one of the oceans. In few words, it is thus explained:—

The earth being divided into two hemispheres by the meteorological equator (not coincident with, but to the north of the mathematical equator), the Atlantic and Pacific oceans are each separated into two distinct basins by it. The Indian Ocean lies almost altogether to the south of it. In each of these separate basins there is a complete circulatory system around a central space, which lies on and near to either tropic. The waters flow from east to west between the equator and the tropics, bending to the northward on the western shores of the Northern oceans, and to the southward on the Southern oceans, then recurving to the eastward, when beyond the tropics it passes over to

* Voyage to the South Pole, vol. ii, pp. 156—384; Journal des Savants, February, 1849, p. 72.

120
135
150
165
180
165
Sea of Behring
Sea of Okhotsk
Kamtschatka
Aleutian Archo
Kurile Is.
JAPANESE CURRENT
Pekin
JAPAN Is
Yesso
Nippon
Osaca
Yedo
Saghalien
Chusan
Bonin Is
Loochoo
Canton
Formosa
Bashee Is
Ladrone Ids
Philippine Islands
Palaos Is
Caroline Ids
Marshall Archo
Ralick Ch.
Ratack Ch.
NORTH EQUATORIAL
EQUATORIAL COU
Molucca Is
Gilbert Archo
Borneo
Celebes
Papua
New Ireland
Solomon Is
Timor
Torres Str.
G. of Carpentaria
Victoria R.
Coral Sea
New Hebrides
Fiji Is
Samoa Is
Society Is
Tonga Is
New Caledonia
Tropic of Capricorn
AUSTRALIA
Moreton B.
Perth
Adelaide
Sydney
Melbourne
Port Phillip
Bass Str.
L.d Howe I.
AUSTRALIAN CURRENT
Kermadec Is
New Zealand
Chatham Is
Auckland Is
ANTARC
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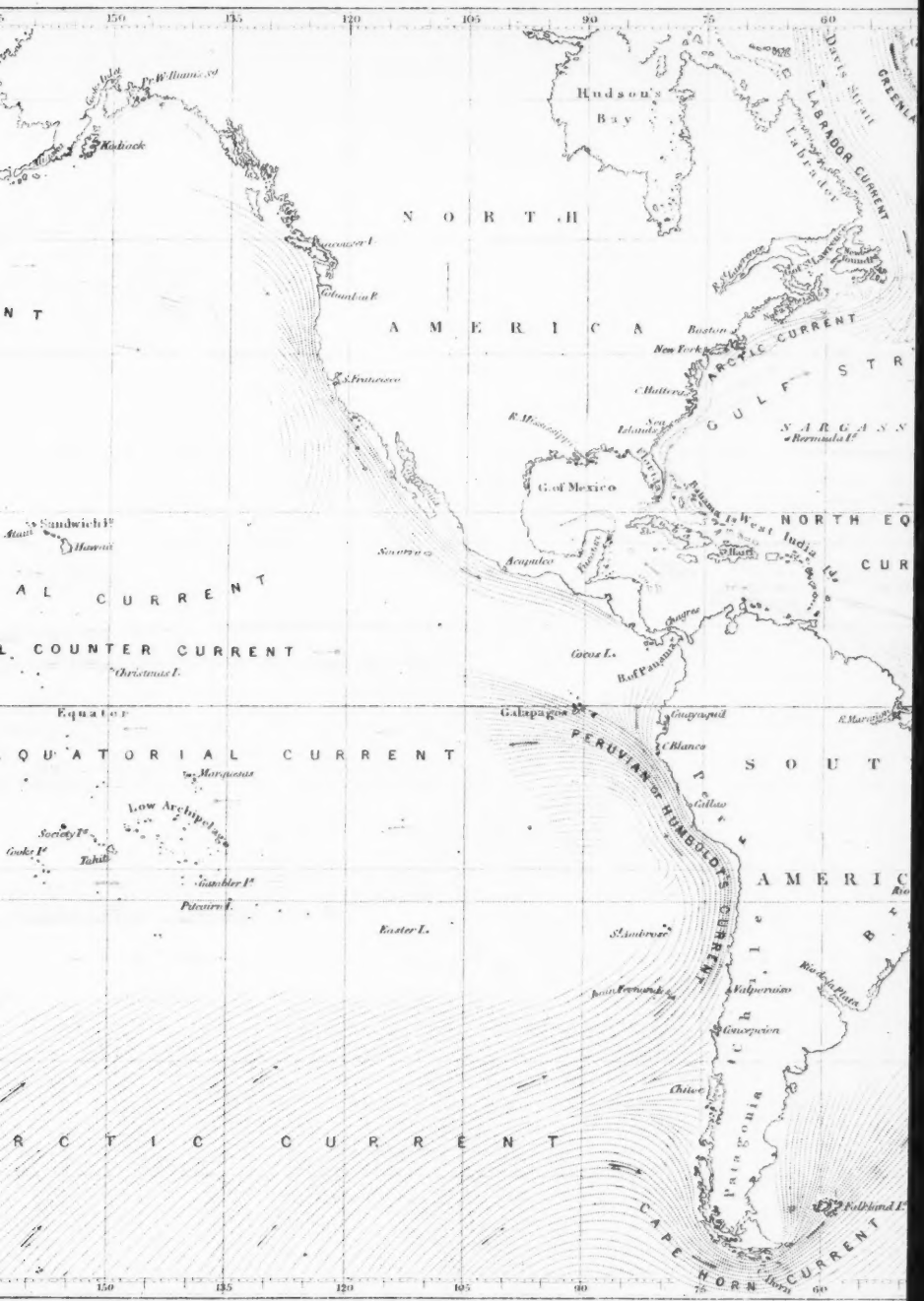
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Hudson's Bay
Davis Strait
GREENLA
LABRADOR CURRENT
Labrador
Pt Williams
Kodiack
N O R T H
A M E R I C A
Vancouver I.
Columbia R.
Boston
New York
ARCTIC CURRENT
S. Francisco
C. Hatteras
GULF STR
Mississippi R.
New Islands
Florida
G. of Mexico
SARGASS
Bermuda I.
Sandwich Ie
Atuai
Owhyee
NORTH EQ
CUR
Nauarro
Acapulco
Panama
Bahama Isds
West Indies
AL CURRENT
L COUNTER CURRENT
Christmas I.
Cocos I.
Bof Panama
Equator
Galapagos
Guayaquil
E. Mariq
QUATORIAL CURRENT
C. Blanco
PERUVIAN OR HUMBOLDT'S CURRENT
S O U T
Marquesas
Low Archipelago
Callao
Society Ie
Cooks Ie
Tahiti
Gambier Ie
Pitcairn I.
A M E R I C
Easter I.
St Ambrose
Rio de la Plata
Valparaiso
Conception
Chiloe
Patagonia
R C T I C C U R R E N T
Falkland Ie
CAPE HORN CURRENT

Greenland
Iceland
Davis Strait
GREENLAND CURRENT
LABRADOR CURRENT
Labrador
EDDY
North Sea
EUROPE
RENNELL'S CURRENT
FRANCE
Boston
ARCTIC CURRENT
GULF STREAM
SPAIN
SARGASSO SEA
Bermudas
Azores
Madeiras
Canary Is.
Tropic of Cancer
NORTH EQUATORIAL
CURRENT
C. Verde Is.
Sierra Leone
GUINEA CURRENT
Bight of Benin
Bight of Biafra
Equator
SOUTH
AMERICA
EQUATORIAL CURRENT
BRAZIL CURRENT
Rio Janeiro
Trinidad
St Helena
Rio de la Plata
Valparaiso
Conception
SOUTHERN CONNECTING CURRENT
Tristan d'Acunha
Cape of Good Hope
ANTARCTIC CURRENT
Falkland Is.
Georgia
Bouvet I.
HORN CURRENT

CHART
of the Prevalent
SURFACE CURRENTS
OF THE OCEAN.

by
A.G. FINDLAY.

Polar Currents are shewn in blue
Tropical Currents red.

the eastern sides of the respective basins, and then turns southward towards the initial portions of the circuits just described.

But between these two basins of circulation in each ocean, there is a well-defined but ill-understood, counter-current, which I believe I first eliminated in its full extent in 1851 and 1853.* For a portion of the year at least it flows to the eastward, in direct opposition to the course of the streams on either side of it, towards the Bight of Benin in the Atlantic and the Bay of Panama in the Pacific. In the Indian Ocean there is an analogous feature found near the Sumatra coast.

There is a complete difference between the northern and southern polar regions in their condition, owing to current influences. This arises from the configuration of the land at the head of the Atlantic (the waters of the North Pacific have no influx into the Polar area), and the absence of land around the Antarctic regions. Owing to the much wider space over which the warmer waters of the southern hemisphere are spread, their force, as exerted on any point, is incomparably less than that which is found in the Atlantic waters, which force their way northward between Iceland and North-West Europe.

If the land which exists near the Antarctic Pole had any coast which faced towards the *west*, the prevalent currents would impinge on it, as they do on the western coast of Europe, and then we may infer that they would find a way behind that icy continent, and so break it up, or allow a passage for the waters behind it. There appears to be something of this sort to the southward of Cape Horn; perhaps Gherritz Land may extend considerably to the southward and westward, for there are constantly vast drifts of ice which pass to the north-east of Cape Horn, in greater extent and quantity apparently than in any other portion of the circuit.

In the north, as is well known, there is a circulation around the Arctic basin, by a current proceeding from the North-East Atlantic, which returns into it by Baffin's Bay. As regards the Pacific, Behring's Strait is too shallow to allow of much current influence passing from it into the Polar basin.

This, then, is a general outline of the movements of the surface of the ocean, in addition to which it may be demonstrated that a portion of each of these circulatory systems finds its way into the adjacent area, and so maintains that continuity of interchange which I wish to inculcate. But when we come to probe beneath this outer film, a very different order of phenomena is encountered, and this field, I earnestly contend, will afford the great harvest for future enquirers in terrestrial physics. We are in no position, as yet, to erect even the basis of a system which will account for the facts which have been recently brought to light.

But this point I insist on—that we now know enough to affirm that the ocean water is of the same constitution, has the same characteristics all over the world, from the equator to the poles, and from the surface to its bed. As regards the surface, it may be contended that

* See Directory for the Pacific Ocean, 1851, vol. ii, pp. 1243—1247; and Report, British Association, 1853, p. 76.

there are normal variations in different zones, but against this I would state my belief that if the observations for specific gravity were uniformly taken in such a way as to be free from the manifestly disturbing influences of rain, evaporation, or freezing, there would be the greatest accordance in all parts of the world. Such a universal similarity of condition can only have arisen from the perpetual interchange of the waters of every known portion of the ocean. As with the atmosphere so with the sea. We are intimate with the motion and causes of the winds on the surface of the earth, but are less so with the upper strata beyond our reach. So with the ocean. We now know that its bed everywhere, and at enormous depths, abounds with animal life. These minute and delicate organisms, probably endowed but with small powers of locomotion, could not exist if the medium in and by which they live were not constantly renewed by some perhaps almost imperceptible movement, which brings new supplies of food within their reach. What would the earth be—what would this great city be—if the air were without motion, and all its exhalations had accumulated over it since its history began?

I may best illustrate what I mean by this continuous circulation of the surface waters, by tracing a portion of water all round the world, and show how there is an interchange of this water through both hemispheres, and I will do this from positive data. I will commence at the South Pole, as being farthest removed from our own shores.

The antarctic current, which appears on the surface outside the polar circle, drifts at first slowly to the northward, and then to the eastward, forming a continuous belt all round the globe, between 40° and 50° south. There are some curious evidences of this continuity, but I cannot now quote them.

Cape Horn stretches southward considerably beyond the limits of this current, and a portion only escapes around it to reach the South Atlantic. The western coast of America intercepts the remainder, and it is then forced to the northward, appearing as the cold northerly current along the Chilian and Peruvian coast. It has a very important influence on the climate of the arid regions, to the northward, by chilling the vapours, and causing the haze and dews which are the origin of the only fertility known in these countries, deprived as they are of the trade wind by the lofty Andes.

When this great cool current arrives near the equator, it assumes a westerly course, probably impelled by the feeble trade wind, and, merging into the great equatorial drift, it increases in magnitude in its westward progress, almost in exact ratio with the increase of power that the south-east trade wind gains as it passes beyond the intercepting influence of the Andes. It then appears as a majestic zone or stream of warm water, 1,800 or 2,000 miles broad, and nearly 8,000 miles long, but of unknown depth.

When it reaches the eastern portions of the great Indian Archipelago, the movement of this mighty volume of water, which has been gradually acquiring heat in its progress, becomes nearly neutralized by some inexplicable process, and its effects, to a large extent, cease. But a portion of the stream passes through the various channels into the

Archipelago and also into the space between Timor, Java, and Australia, and hereabouts the surface temperature is at a maximum. Another portion passes southwards down the Australian coast, forming a minor gulf stream, and has the same effect on the vegetation as its prototype has on the cotton plantations on the sea islands of Georgia.

The Pacific Current therefore forms the head waters, as it were, of the analogous drift in the Indian Ocean, but it is here of much less extent than in the Pacific, but it reaches the coast of Madagascar and South East Africa as a more powerful stream than that which drifts on the Eastern Archipelago. Passing rapidly southwards, around the southern extremity of Africa, it assumes the well-known name of the Agulhas Current, a swift, well-defined, but narrow stream of heated water, which rushes past the southern edge of the bank of soundings until it reaches the meridian of the Cape of Good Hope. Here there is a singular movement and interchange of waters going on, which has been the subject of much investigation and discussion. It was this current and its apparent anomalies which first called the attention of Major Rennell to the subject; this was in 1764, and in 1777 the first good essay on current specialities appeared as evidence in this Agulhas Current. The definite conclusions then arrived at by Major Rennell have been almost entirely confirmed by the more refined investigations carried on by the Utrecht Meteorological Institute in 1857,* and still later by the observations and deductions of Capt. Henry Toynbee.†

The general result of this examination is that the Agulhas Current, instead of passing westwards around the Cape of Good Hope and then drifting northwards, seems to be repelled by the cold Antarctic Drift coming from the west and south-west, and greatly lowering the temperature of Table Bay, &c., and that only a portion of its warm waters unite with this cold current, which turns northward along the west coast of Africa. A large portion of the Agulhas Current seems to return upon its own course to the southward and eastward, and thus augment the southern connecting current.

However, there is sufficient admixture of its waters with the eastward stream to permit us to affirm that some portion of the South African Current is derived from that current. This current flows northward up the African coast, as a similar current does along the western coast of South America. Passing onward, until near the Equator, it assumes a westerly direction, and then forms the initial course of the southern Equatorial Drift of the Atlantic, which flows westward at a rate of from 12 to 20 miles per diem, and is nearly 2,000 miles broad. Increasing in warmth and velocity, it reaches the coast of South America, where it is divided, one portion flowing southwards down the Brazilian Coast, the other passing with great velocity to the W.N.W., past the Coast of Guayana, and joining the northern branch of the Atlantic Equatorial Stream, which, together, have a

* (Temperatures of the Sea south of the Cape of Good Hope). Uitkomsten van Wetenschap, &c. Koning. Nederl. Meteorol. Institut, Utrecht, 1857 and 1859.

† Capt. H. Toynbee "On the Specific Gravity, &c., of the Seas between England and India." Journal Royal Geographical Society, vol. xxxv, 1865, p. 153.

breadth of not less than from 2,000 to 2,200 miles. The streams thus united then impinge on the eastern faces of the Caribbee Islands; and here another great difficulty arises. The streams, in their long progress beneath a tropical sun, have become very warm, and their velocity is considerable, so that, theoretically, they should rush through the openings between the islands with redoubled velocity, as the islands diminish the water-way by one-half; but no such phenomenon occurs. The streams through the Archipelago are constant, but not violent; so little so, that at times there is a current in the sea south of Cuba, in a reverse direction.* Still there is sufficient force in their impetus to drift with great velocity into the Gulf of Mexico through the strait between Cuba and Yucatan.

I have now shown that there is a current more or less continuous all the way from Cape Horn to the head waters of the famous Gulf Stream.† I have not alluded more than was necessary to the other branches of the currents which are also intimately connected with, and partially derived from, the same sources.

Some months ago I ventured to controvert an opinion, which I found was entertained by many, that the fluctuations of the Gulf Stream had an intimate relation with the changes of climate in our country.‡ I must confess that I was much surprised that such an opinion should still prevail; and I have been still more surprised at the opposition which has been offered to the deductions which I printed more than ten years ago, as I believed that they were coincided with by all who took any interest in the subject. As this brings us nearer home, I will dilate more fully on it, as it will more completely illustrate the points I now wish to demonstrate.

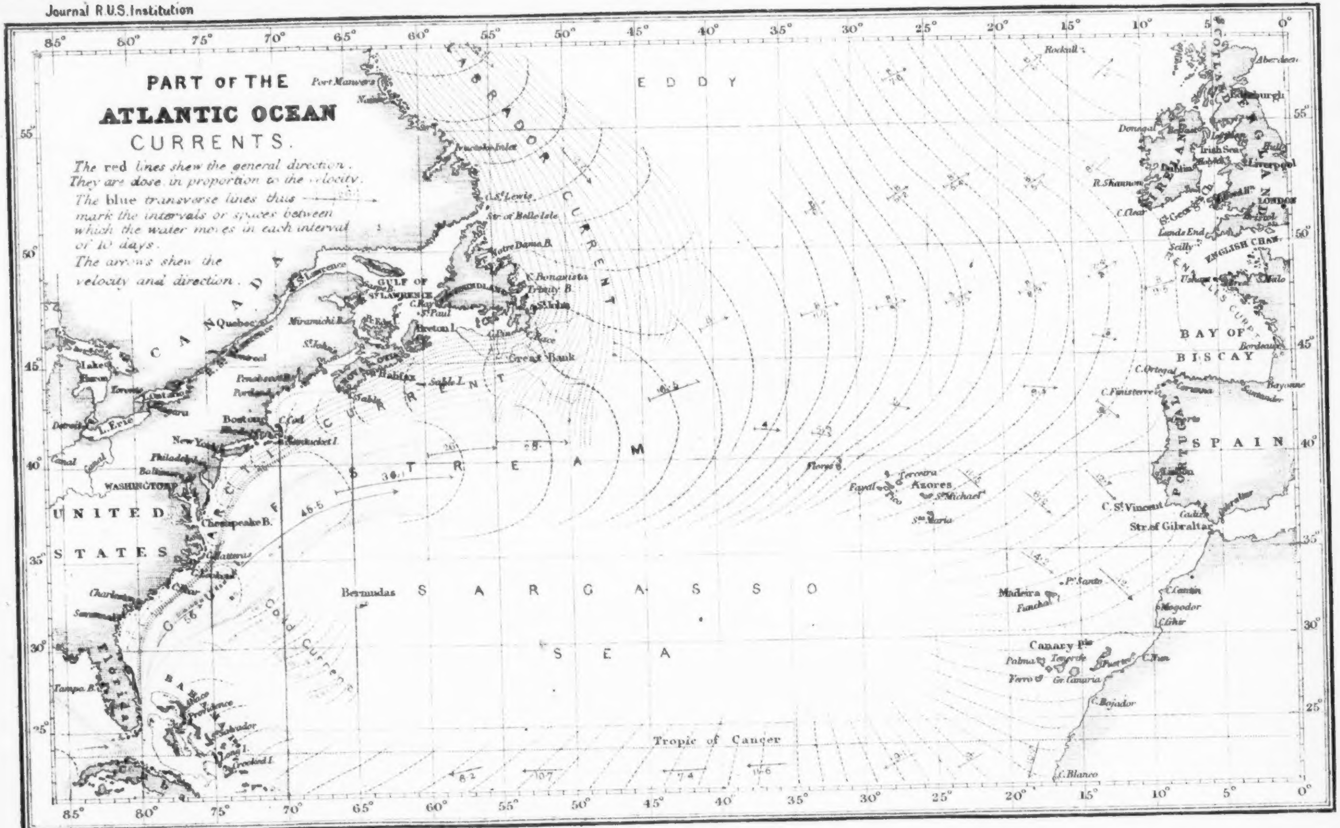
In estimating theoretically the volume of the Gulf Stream, we met with a difficulty at the outset. The whole area of the North Atlantic, between latitudes 25° or 28° north and 10° or 12° south, is drifting on the surface with considerable rapidity, towards the West India Islands and the Gulf of Mexico, the rate varying from 15 to 22 miles per day; and this tropically heated water, which covers an area of not less than 5,400,000 square miles, is represented by the outlet of the comparatively puny Gulf Stream, not 40 miles wide and 1,200 feet deep, a breadth not more one-six hundredth part of the parent source.

The Gulf Stream, at its commencement, is confined between the coast of Florida and those of Cuba and the Bahama Banks, and no other water can reach it during this part of its course. The first section—that at its westernmost limit—was examined in 1858, between the Dry Tortugas and the entrance to the Havana, a distance of 98 miles, which showed that the water gradually deepened from the north side to the maximum depth of 770 fathoms, within 5 miles of the Cuban shore. The next section will be more suitable for my demonstration.

* Colombian Navigator, by John Purdy, 1839, vol. iii, p. 231, &c.

† A very excellent monograph on the Gulf Stream, in which nearly every author who has mentioned it is alluded to, thus forming a complete history, is entitled, "Geschichte des Golfstroms, und seiner Erforschung," by J. G. Kohl, Esq., Bremen, 1868.

‡ Proceedings Royal Geographical Society, Feb. 8, 1869.


PART OF THE
ATLANTIC OCEAN
CURRENTS.
The red lines shew the general direction.
They are close in proportion to the velocity.
The blue transverse lines thus
mark the intervals or spaces between
which the water moves in each interval
of 10 days.
The arrows shew the
velocity and direction.
LABRADOR CURRENT
EDDY
GULF STREAM
SARGASSO SEA
Cold Current
Tropic of Cancer
CANADA
UNITED STATES
Florida
IRELAND
ENGLAND
SCOTLAND
BAY OF BISCAY
SPAIN
PORTUGAL
Azores
Madeira
Canary Is.
Bermudas
Great Bank
GULF OF ST LAWRENCE
Newfoundland
Nova Scotia
Quebec
Boston
New York
Philadelphia
Baltimore
WASHINGTON
Chesapeake B.
Charleston
Savannah
Tampa B.
L. Erie
Lake Huron
Detroit
Halifax
Sable I.
C. Cod
Nantucket I.
Bahama
Providence
Long I.
Crooked I.
Port Manvers
Str. of Belle Isle
Notre Dame B.
C. Bonavista
Trinity B.
St. Johns
Cape Race
Rockall
Aberdeen
Edinburgh
Donegal
Belfast
Irish Sea
Dublin
Liverpool
R. Shannon
C. Clear
St. George's Ch.
LONDON
Bristol
Lands End
Scilly
ENGLISH CHAN.
Ushant
St. Malo
Bordeaux
Bayonne
C. Ortegal
Corunna
Santander
C. Finisterre
Oporto
Lisbon
C. St. Vincent
Cadiz
Gibraltar
Str. of Gibraltar
Flores
Fayal
Pico
Terceira
St. Michael
Sta. Maria
Pt. Santo
Funchal
C. Cantin
Mogador
C. Ghir
C. Nun
Palma
Teneriffe
Ferro
Gr. Canaria
Fuerteventura
C. Bojador
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36.1
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In 1866 it became necessary to lay an electric cable between the Florida Keys and the Havana, and the United States Coast Survey, under Mr. Hilgard, undertook the examination of the bottom. The line of soundings was carried from Sand Key to the Moro Castle of Havana, in a diagonal line across the main strength of the stream, where it first enters the channel which gives its name—a distance of 82¼ miles. To this particular attention is drawn, as it contains the clue to the real character of the Gulf Stream.

Of this breadth of 82 miles, the Gulf Stream does not occupy more than 40 miles on the southern side of the channel, and it was found that the depth of the stream was not more than *one-third* of the entire depth of the channel, or about 1,200 feet, not reaching to the summit of a submarine ridge which was discovered here.*

Such a well-established fact at once overturns all former speculations as to its enormous depth, and high temperature to all depths; for it was found to have only a temperature of 60° Fahr. on the summit of the submarine ridge, and only 45° at the bottom. It will thus be no great sacrifice to abandon preconceived opinions.

In place of troubling you with figures to further prove this point, a single fact will suffice to show that the Gulf Stream does not fill this narrow channel.

Between 1857 and 1862 Capt. E. B. Hunt, of the United States' Engineers, was employed at Key-West, one of the Floridas, on the threshold of the stream.† His careful observations fully bear out the elaborate geological survey by Prof. Agassiz in 1850–51,‡ and demonstrate that these Keys and reefs are slowly, but surely, extending to the *westward* by the mechanical agency of a counter-current north of the Gulf Stream, in direct opposition to the strongest part of the course. During strong weather, the sea about the reefs becomes milky or "white water," from the bottom being stirred up by the waves. This white water is inevitably drifted to the *westward*, and the matter it carries is slowly deposited both north and south of the line of Keys, and to 30 and 40 miles to the southward of them.

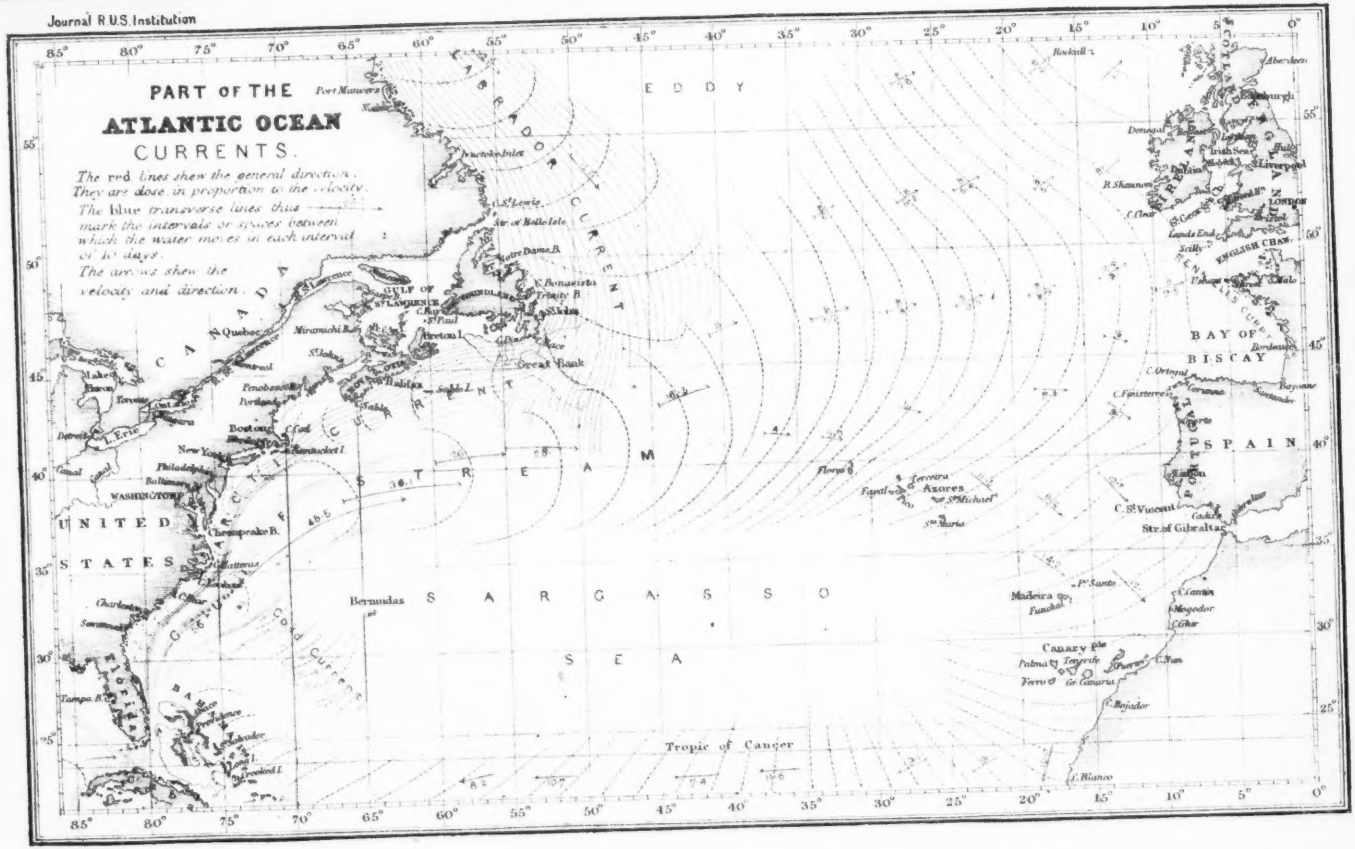
I pass by the other sections of the stream principally made by Commander Craven in 1859, which quite corroborate the observations made on either side. We come to the point which determines the whole, the narrows between Cape Florida and the Bemini Isles. It is the narrowest and also the *shallowest* part of its course. This latter assertion was received at first with some incredulity, as it was in opposition to all previous theory; but it cannot now be controverted. It was obtained by Commander Craven in 1855.§ The distance between Cape Florida and the Bemini Isles is 40 miles, and the maximum depth is only from 300 to 370 fathoms. The temperature of the water at the bed was only 49°; so that here again the warm water

* See abstract of a paper read before the U.S. Academy of Sciences, by Henry Mitchell, Esq. American Journal of Science, Jan. 1867, pp. 69–74.

† American Journal of Science, &c., vol. xxxv, pp. 197–210, and pp. 388–396.

‡ Professor L. Agassiz in Report of U.S. Coast Survey, 1851. Appendix 10, p. 145, 1860.

§ U.S. Coast Survey Report, 1856.


PART OF THE
ATLANTIC OCEAN
CURRENTS.
The red lines shew the general direction.
They are close in proportion to the velocity.
The blue transverse lines thus
mark the intervals or spaces between
which the water moves in each interval
of 10 days.
The arrows shew the
velocity and direction.
EDDY
GULF STREAM
CANADA
UNITED STATES
Bermudas
SARGASSO SEA
Cold Current
Tropic of Cancer
Azores
Madeira
Canary Is.
BAY OF BISCAY
SPAIN
Str. of Gibraltar
Great Bank
Halifax
New York
Boston
Philadelphia
WASHINGTON
Charleston
Florida
Tampa B.
Cape Hatteras
Chesapeake B.
Cape Race
St Johns
Quebec
Montreal
Toronto
L. Erie
Detroit
Penobscot B.
Portland
Nantucket I.
Miramichi R.
Anticosti I.
Gulf of St Lawrence
Port Manvers
Hudsons Inlet
C. St Lewis
Ile de Belle Isle
Notre Dame B.
C. Bonavista
Trinity B.
Skelin
Breton I.
Cape Ray
Sable I.
Bermuda
Abaco
Providence
Lauderdale
Key West
Havana
Matanzas
Bahama Is.
Grand Bahama
Florida Str.
Yucatan Inlet
Aberdeen
Edinburgh
Dundee
Donegal
Belfast
Dublin
Irish Sea
Liverpool
Hull
R. Shannon
Cork
LONDON
Thames
Lands End
Scilly
ENGLISH CHAN.
Falmouth
Calais
Cape Finisterre
C. Ortegal
Bayonne
Bordeaux
Lisbon
Cadiz
C. St Vincent
Gibraltar
Fayal
Pico
Terceira
St Michael
St Maria
Flores
Madeira
Funchal
P. Santo
Canary Is.
Palma
Teneriffe
Ferro
Gr Canaria
C. Bojador
C. Blanco
C. Verd Is.
C. Clear
Rockall
Tropic of Cancer

In 1866 it became necessary to lay an electric cable between the Florida Keys and the Havana, and the United States Coast Survey, under Mr. Hilgard, undertook the examination of the bottom. The line of soundings was carried from Sand Key to the Moro Castle of Havana, in a diagonal line across the main strength of the stream, where it first enters the channel which gives its name—a distance of 82¼ miles. To this particular attention is drawn, as it contains the clue to the real character of the Gulf Stream.

Of this breadth of 82 miles, the Gulf Stream does not occupy more than 40 miles on the southern side of the channel, and it was found that the depth of the stream was not more than *one-third* of the entire depth of the channel, or about 1,200 feet, not reaching to the summit of a submarine ridge which was discovered here.*

Such a well-established fact at once overturns all former speculations as to its enormous depth, and high temperature to all depths; for it was found to have only a temperature of 60° Fahr. on the summit of the submarine ridge, and only 45° at the bottom. It will thus be no great sacrifice to abandon preconceived opinions.

In place of troubling you with figures to further prove this point, a single fact will suffice to show that the Gulf Stream does not fill this narrow channel.

Between 1857 and 1862 Capt. E. B. Hunt, of the United States' Engineers, was employed at Key-West, one of the Floridas, on the threshold of the stream.† His careful observations fully bear out the elaborate geological survey by Prof. Agassiz in 1850–51,‡ and demonstrate that these Keys and reefs are slowly, but surely, extending to the *westward* by the mechanical agency of a counter-current north of the Gulf Stream, in direct opposition to the strongest part of the course. During strong weather, the sea about the reefs becomes milky or "white water," from the bottom being stirred up by the waves. This white water is inevitably drifted to the *westward*, and the matter it carries is slowly deposited both north and south of the line of Keys, and to 30 and 40 miles to the southward of them.

I pass by the other sections of the stream principally made by Commander Craven in 1859, which quite corroborate the observations made on either side. We come to the point which determines the whole, the narrows between Cape Florida and the Bemini Isles. It is the narrowest and also the *shallowest* part of its course. This latter assertion was received at first with some incredulity, as it was in opposition to all previous theory; but it cannot now be controverted. It was obtained by Commander Craven in 1855.§ The distance between Cape Florida and the Bemini Isles is 40 miles, and the maximum depth is only from 300 to 370 fathoms. The temperature of the water at the bed was only 49°; so that here again the warm water

* See abstract of a paper read before the U.S. Academy of Sciences, by Henry Mitchell, Esq. American Journal of Science, Jan. 1867, pp. 69–74.

† American Journal of Science, &c., vol. xxxv, pp. 197–210, and pp. 388–396.

‡ Professor L. Agassiz in Report of U.S. Coast Survey, 1851. Appendix 10, p. 145, 1860.

§ U.S. Coast Survey Report, 1856.

does not extend more than one-third or one-half the entire depth, demonstrating the cubical amount of warm water passing over this line to be nearly the same as that shown in the first section, from which this is distant about 250 miles.

The Gulf Stream, at its outset, is thus not more than 39½ miles wide and 1,200 feet deep.

The velocity of the stream has also been much exaggerated in most works that I have seen of late. Its mean annual velocity, in its *swiftest* part, from all the data I have been able to obtain, is 65·4 miles per day. It is more in summer, less in winter.*

Now, as the present inference is, that the cold substratum of the Gulf Stream is moving in a direction opposite to it, there is some point where there is no movement. Making all due allowance for the decrease in velocity from 65·4 miles per day on the surface to 0·0 at the bottom, I calculate that the mean velocity of the whole mass is 49·4 miles per day. As the sectional area of the stream does not exceed 6·64 square miles, it follows that there is not more than from 294 to 333 cubic miles of water per day passing over a given line in this part of its course. These figures give an amount of less than one half what is usually stated, but I think that they cannot be contradicted with our present knowledge.

Its progress beyond this may be briefly passed over. From the entrance into the Gulf of Florida to the Narrows is about 330 miles. To the northward of this it appears as a series of alternate warm and cold bands, or rather the warmest of four of these belts, having the Arctic and very much colder current flowing southwards to the west of it.

The warm belt of the true Gulf Stream is so pressed upon the coast, that the exactly defined separation between its dark blue and tepid waters, and the lighter and colder Arctic current has been called the "cold wall." This remarkable feature becomes undistinguishable to the north-westward of New York, when the stream bears off to the eastward.

In a period of 10 days after leaving the Narrows, it arrives off Cape Hatteras, with a loss of only 3° of its initial temperature, and in 20 days, it is off Nantucket, being 14° or 15° cooler still, and it is this rapid course, and consequent preservation of its original warmth, that has made it so remarkable in all ages. But beyond this its characteristics rapidly diminish.

In 50 days it is off the banks of Newfoundland, and its temperature will be found to be only 51° in the summer. The question of season is a most important one in this discussion, and it will, as it seems to me, increase the difficulties very much, in referring the higher tem-

* The fluctuations in the velocity of the Gulf Stream are very great, and occur apparently without any known cause. This may arise from a variation in the sea level, as affected by tidal influences, for Professor A. D. Bache in his report on the tides of Key West (Florida Islands), (U.S. Coast Survey Report, 1853, pp. *75, *76), shows that the mean level there is one foot *higher* when the moon is on the equator, than at its greatest declination. In the north Atlantic the reverse is the case; here it is three inches higher at the maximum than at the least declination.

perature on the European coast to the stream coming from Newfoundland. I have said that it takes usually 50 days for the *surface* water to pass from Cape Florida to the banks of Newfoundland, but it is more than probable that the entire current travels more slowly, the velocity decreasing with the depth. On this point our knowledge is very limited.

The water then, which leaves the Gulf of Florida in May, when the Gulf Stream has a high velocity, and with considerably above its average warmth,—about 81° as a mean,—reaches the Banks in July, and this is the period when the Arctic current is strongest, and also much cooler, from the amount of ice, icebergs, and dissolved snows from the Arctic regions, which it transports rapidly southward. The temperature east of the banks is not more than 40° to 45° in June. In January it is down to 30°.

The distance thus travelled is about 3,500 miles along the course of the stream, and its surface-velocity is not more than one-third that of its commencement. It has expanded in breadth from under 40 miles to 300 at Nantucket, and to nearly 400 miles south of the Newfoundland Banks, or ten times its original breadth, so that over a given line, the depth of the water which passed through the Gulf of Florida, cannot be more than 120 or 100 feet thick. But it is so cooled down, that it is cooler on the surface than it was at the bottom at the outset. It has lost all the extra warmth it possessed, and the volume of water above the temperature of 70° in the Narrows will not form a film more than 60 feet thick off Newfoundland.

My second point is, that it is here more than neutralized, as a warm current, by the Arctic current, impinging on its northern edge. The struggle between the Arctic and Tropical currents is here so strongly marked, that the interlacing of the warm and cold waters has been compared to the clasped fingers of the hands, and the veins of each of these distinctly-marked ocean-waters are so well defined that a very short distance, frequently a few yards, is sufficient to carry a ship into or out of the Tropical waters.

One feature of this down-bearing cold current is very distinctly marked at all seasons, and deserves especial attention.* It is shown on the diagram by an irregular isothermal line, which is no fancied division, as it is the mean isotherm between the temperatures of 50° in winter, and 60° in the summer. This blue space shows that there is a cold water gulf penetrating from 150 to 200 miles southward of its general limit, and it therefore entirely intersects the surface waters of the easterly stream for that portion of its northern breadth, which is, for our purpose, the most important part of its course.

The thus cooled water of this northern branch still pursues an easterly direction, and the southern and warmer portion drifts onwards also, until it is finally lost, as an independent stream, about the Azores.

I have a curious evidence to demonstrate that hereabout there is a division between the waters which flow *north*-eastward and those which pass to the eastward.

* See Thermal Chart of the North Atlantic. U.S. Hydrographic Bureau.

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It has been for many years the custom of shipmasters to throw overboard bottles, loaded with a little sand, &c., and containing a slip of paper with the particulars of the position of the ship. These current-bottles have been picked up in various parts of the world, and have been exceedingly useful in determining the general drift and velocity of ocean-currents. The particulars of most of these have been collected by Capt. Becher, and their general routes shown on a chart published by the Admiralty. This very interesting "Bottle-chart" is well known to Hydrographers. I possess the most curious of these bottle-papers.* It was thrown overboard on Sept. 28th, 1826, from H.M.S. "Blonde," the vessel which carried from England the bodies of the King and Queen of the Sandwich Islands.

This remarkable bottle was picked up by a fisherman on June 15th, 1841, on the rocky beach of La Forêt, in Concarneau, on the coast of Brittany, after an interval of 14 years and nine months.

Now whether this bottle had, in this long interval been circulating around the Sargasso Sea, had become entangled in the weeds of that still area, or had been buried in the sandy beach of one of the West India Islands, none can tell. That it had passed around the polar basin, running the gauntlet of the Arctic ices, none can believe. But it proves one point, that the spot from whence it started, was not within the area of those waters which drift to the *northward*. I may add that the enclosed paper was forwarded from Brittany to the President of the Royal Geographical Society, and finally reached the gentleman to whom it was addressed.

The third point I propose to show is that the N.E. stream past the British Islands cannot be taken as the Gulf Stream.

On the eastern side of the Gulf, if I may so call it, of cold water to the east of the Newfoundland Banks, the temperature of the surface rises very considerably. It rises from 20° to 27° above that on the Banks and in this Gulf. How can this be the Gulf Stream? It cannot again acquire heat. This warmth must be derived from more *southern* sources. It may be thought that it is an "eddy" northward as Mr. Whitley says, but the surface drift shows no such eddy.

But the evidences of an easterly drift pass beyond this. The cocoa-nuts, tropical seeds, and many other evidences of tropical origin are thrown on our western shores, and also on the coast of Norway and Iceland, and the mahogany log drifted on to Greenland and made into the Danish Governor's dining-table may have come through the Gulf Stream. But the water is *not continuously warm*, as I have shown, and therefore what warmth, above the normal condition, it possesses, must come from other directions.

It will take a floating body about 150 days to reach the Land's End from the Grand Banks; the great body of water probably much longer. So that the water which washes the coast of Devonshire must have left the West Indies at least nine months previously, and probably much longer, passing through all the vicissitudes of the seasons, so that the water which left Florida in April or May, at the *warmest*, is at New-

* It is No. 65 on Captain Becher's Bottle Chart.

foundland in June at its *coldest*, and at Penzance in January, also at the *coldest*.

The temperature of the surface of the ocean, eastward of longitude 40° W, is remarkably uniform and constant. A ship sailing eastwards in the winter months, after passing the belt of coldest water into that of warm water, comes into an area of lower temperature of about 54° to 51°, the latter being that of the sea at Penzance in January. In July it is about 60°. It is to this uniformity and high winter temperature that the warm winter climate of Devonshire and Cornwall are owing.

But this amenity of winter-climate and ocean-warmth extends as far as the North Cape, and to the south coast of Iceland, so that there is an area of the ocean not less than 1,500,000 square miles in extent, above the normal temperature.

To attribute this higher temperature to the Gulf Stream is to ignore the statistics of that stream.

The actual bulk of water which passes through the Florida Channel is from 294 to 330 cubic miles per day, and it receives no accessions from the tropics.* Fully one-half of this passes eastward and *southward* from the Banks of Newfoundland, and the northern half, cooled down and neutralized by the Arctic current, has according to this theory, to cover this area to raise its temperature. The known bulk of the Stream will only give *six inches per diem* over this area. And I would ask how is it possible that such a minute film can have any influence; and this too at from one to two years after it has left the Gulf of Florida as the true Gulf Stream.

I will not advert to the further progress of this warmer water, which may be traced to and beyond Spitzbergen, and its effects throughout the north Polar basin, and these effects I contend are totally and absolutely incompatible with the now well-known particulars of the Gulf Stream proper.

I cannot now go into the question of the isothermal lines, which show most markedly the higher temperature in the winter, and much less so in the summer. The equable temperature of the waters causes this change in the relation of the warm and colder waters. But the process is going on constantly.†

It has been propounded by Mr. Croll that the modern method of determining the amount of heat, will account for all the phenomena popularly attributed to the Gulf Stream.‡

* The Thermal Charts show great irregularities of temperature to the N.E. of the Bahama Islands, and the few current observations here recorded also negative the theory that the equatorial current recurves to the northward outside of the Bahama Islands.

† Besides the charts in Professor Dove's work on the "Distribution of Heat," the extent of this N.E. stream is very clearly shown by the observations collected by Professor H. Mohn, Director of the Meteorological Institute of Norway at Christiana. These charts and observations show that it is a narrow stream of warmer water, which does not begin to be manifest till near the coast in about lat. 50° or 52°, and is not more than 100 or 150 miles broad at its maximum heat. See "Temperatures de la Mer entre l'Islande, l'Ecosse et la Norvège," par H. Mohn, Christiania, 1870.

‡ See Geological Magazine, vol. vi, April, 1869; and Philosophical Magazine, Sept., 1869, and February, 1870.

But I would deferentially demur to his calculations. He takes no account of the time it takes for the water to circulate. He doubles, as I think, the volume of the stream, and does not refer to the interferences it encounters. However valuable his suggestions may be, they must be applied in a different way.

How, then, can the phenomena of our warm winter climate be accounted for? The reason seems to me to be simple and obvious. The great belt of south-west winds, called the Anti-Trade or Passage Winds, passes over the North Atlantic throughout its breadth, and drives slowly the whole surface of the water to the northward of an easterly course, or towards the shores of North West Europe. From the particular configuration of the land, this north-east drift is allowed to pass into the Polar area. This south-west wind infuses into high latitudes the temperature and moisture of much lower parallels, and by its greater rate of travelling, passes over the warmer water to the southward, and this brings to our southern coasts in *one day* the warmth of the centre of France.* By its variation from westward or eastward of a southerly direction, we find all the variations in moisture which is induced by this wind passing over land or sea.†

I trust that I have made myself intelligible, and that the subject will receive much more attention than it has hitherto done.

The excellent observations made on the expeditions from the Royal Society under Dr. Carpenter and Dr. Wyville Thompson will, I have no doubt, throw great light on this obscure north-east current, which should *not be called the Gulf Stream*, but should possess a specific term.

It was for a long period supposed that this north-east drift of warmer water was confined to a belt extending for a moderate distance from the coasts of north-western Europe. But from the observations made for a long series of years by the Royal Danish ships which pass between Denmark, Iceland, and Greenland, which have been ably discussed by Admiral Irminger of the Danish Navy, it is shown that this warmer water extends to the meridian of the west coast of Iceland, and even more westerly.

He has demonstrated from observations made in 1867, 1868, and 1869, that these warmer belts are encountered between the Faroe Islands and Iceland; and that there are usually two of these belts

* A moderate breeze of No. 4 of the Beaufort, or No. 2 of the Glaisher Notation, has a velocity of from 291 to 650 feet per second, or from 8 to 12 miles an hour. Such a wind will pass from the latitude of the south of France to the south coast of England in from thirty to forty hours, and bring with it much of the warmth of that latitude.

† See Thomas Hopkins, Esq., "On the Causes of the Mild Winter Temperature of the British Islands," Journal Royal Geographical Society, vol. xxxvii, pp. 206–220. The author attributes the warmth to the condensation of vapour brought by the S.W. winds. A later authority will steer the courses of these S.W. winds more clearly. In an elaborate memoir by Alex. Buchan, Esq., M.A., Secretary to the Scottish Meteorological Society, it will be seen by reference to the illustrations, that the S.W. winds prevail throughout the year, in a very marked degree, on the sea coasts of N.W. Europe; a great contrast to the winds in the western part of the Atlantic in the same latitudes. See Transactions of the Royal Society of Edinburgh, vol. xxv, 1869.

or veins of water from 4° to 5°·6 higher in temperature than the water on either side of them.*

This is very remarkable, and I do not know of any theory which will account for their existence, and it will be necessary to have further and similar observations to the southward before they can be connected with that portion of the ocean better known.

Of the further progress of this stream, how it enters the Polar basin, and so drives back the line of ice between Spitzbergen and the coast, it is not necessary for me to speak. It has all been exhaustively discussed by Dr. Petermann. The same with its outlet through the Arctic Archipelago, the effects and operations of which are familiar to all.

I have thus traced a complete system of surface motion all around the globe. To follow it in its details would be a long task, and out of place here, but I hope that I have demonstrated that the circulation of the ocean must have a most important bearing on the distribution of those effects which it exercises on its shores, on the distribution of climate, and its bearing on navigation.

* Admiral Irminger has thrown great light on the temperature and movements of the surface waters of the Atlantic between Shetland and Greenland. Besides the insuperable difficulties of referring its warmth to the Gulf Stream, the rate of its progress northward, not exceeding from 1½ to 2½ miles per day, renders such a position still more untenable. See Proceedings Royal Geographical Society, 1869.

Evening Meeting.

Monday, March 7th, 1870.

REAR-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 21st February and 7th March, 1870.

LIFE.

Stewart, H. B., Lieut. R.N. 9*l.*
Birch, G. F., Captain Hants Mil. 9*l.*

ANNUAL.

Shewell, W. V., Lieut.-Col. Bo. Staff Corps. 1*l.*
Blood, F. G., Lieut. 1st Som. Mil. 1*l.*
Skinner, P. K. M., C.B., Major-General Bo. Staff Corps. 1*l.*
Mitchell, J. C., Capt. Middx. Vic. Rifle Volrs. 1*l.*
Marshall, G. F. L., Lieut. R.E. 1*l.*
Bingham, W., Lieut., late 5th Fusileers. 1*l.*
King, L. S., Capt. 88th Regt. 1*l.*
Douglas, George M., Lieut. 33rd Regt. 1*l.*
Grant, C. F., Colonel, late Bo. Army. 1*l.*
Watson, F. G. D., Capt. Hants. I. of Wight Art. 1*l.*
Metcalf, John A., Lieut. Mon. Mil. 1*l.*
Anstey, T. Henry, Lieut. R.E. 1*l.*

IRONCLADS, PRESENT AND FUTURE.

By CHARLES F. HENWOOD, Esq., N.A.

The CHAIRMAN: I have to announce that Mr. Henwood will read a paper this evening on "Ironclads, Present and Future," and I wish to express to the meeting the regret which the Council feel that in consequence of Captain Coles being engaged on duty in connection with the trial of the "Captain," his new vessel, he is unable to read his paper on "Turret Ships." The Council are quite aware that it is often a great inconvenience to members and others that the lectures should be changed; but in this instance it has not been their fault, nor indeed anybody's fault; and if any gentleman present, or any member, has not received due notice of the change, it has not arisen from any neglect on the part of the Officers of the Institution. The

change of lecture has been advertised as widely as possible; but very often the notices do not get into the hands of members. We all feel obliged to Mr. Henwood, who, on a very short notice, has undertaken to supply Captain Coles's place.

Mr. Henwood: To prevent any misunderstanding from the fact of this evening having been set apart for the reading of a paper by Captain Cowper Coles, C.B., R.N., and of my former professional connection with that gallant Officer, I wish it to be clearly and distinctly understood, that I in no way pretend to set forth his views or ideas on any matter whatever, nor those of my other gallant friend, Admiral Halsted. I alone am responsible for the subject matter of my paper.

This subject is one of very great interest, and of vital national importance.

It naturally divides itself into two heads, viz.: "present ironclads" and "future ironclads."

First, then, let us consider our "present ironclads" in their collective character, in order that we may see whether they do, or do not, fulfil the requirements of our Navy, as a fleet for maximum, uniform, combined operations, under steam or sail power; and then in their individual character, in order that we may see whether any progress has been made since their introduction in 1859, and whether there exists, either built or building, any one vessel which may form a suitable type on which to found a specific and efficient class.

When the Navy Estimates were laid before Parliament last year, it was announced that our ironclads had been classified in a way that would be thought intelligible to the "House," viz., as follows:—

Table A.

Broadside Ironclads.

1st Class, 2 *Vessels.*

Name.	Length in feet.	Tonnage.	H. P.	Speed.	No. of Guns.	Weight of Broadside in lbs.
Hercules	325·	5234·	1200·	14·6	12	2080·
Sultan	325·	5226·	1200·	14·6	12	2080·

2nd Class, 6 *Vessels.*

Audacious	280·	3774·	800·	13·5	10	1250·
Invincible	280·	3774·	800·	13·5	10	1250·
Vanguard	280·	3774·	800·	13·5	10	1250·
Iron Duke	280·	3774·	800·	13·5	10	1250·
Swiftsure	280·	3893·	800·	13·5	10	1250·
Triumph	280·	3893·	800·	13·5	10	1250·

3rd Class, 9 *Vessels.*

Name.	Length in feet.	Tonnage.	H. P.	Speed.	No. of Guns.	Weight of Broadside in lbs.
Bellerophon	300·	4270·	1000·	14·1	18	1600·
Lord Warden	280·	4080·	1000·	13·4	20	1400·
Lord Clyde	280·	4067·	1000·	13·4	24	1300·
Minotaur	400·	6621·	1350·	14·4	26	2150·
Agincourt	400·	6621·	1350·	14·4	26	2150·
Northumberland	400·	6621·	1350·	14·4	26	2150·
Royal Alfred	273·	4068·	800·	12·3	12	1530·
Repulse	252·	3749·	800·	12·4	12	1360·
Penelope	266·	3096·	600·	12·7	11	1080·
4th Class, 8 *Vessels.*						
Achilles	380·	6121·	1250·	14·3	26	1765·
Royal Oak	273·	4056·	800·	12·5	24	1510·
Prince Consort	273·	4045·	1000·	13·1	24	1510·
Caledonia	273·	4125·	1000·	13·0	24	1510·
Ocean	273·	4047·	1000·	12·8	24	1510·
Valiant	280·	4063·	800·	12·6	18	1100·
Hector	280·	4089·	800·	12·3	18	1100·
Zealous	252·	3716·	800·	12·4	10	565·
5th Class, 4 *Vessels.*						
Warrior	380·	6109·	1250·	14·3	32	1970·
Black Prince	380·	6109·	1250·	14·0	32	1970·
Defence	280·	3720·	600·	11·6	16	985·
Resistance	280·	3710·	600·	11·8	16	985·
6th Class, 2 *Vessels.*						
Pallas	225·	3372·	600·	12·4	8	464·
Favourite	225·	2094·	400·	11·8	8	524·
7th Class, 5 *Vessels.*						
Enterprise	180·	993·	160·	9·9	4	230·
Research	195·	1253·	200·	10·3	4	230·
Viper	160·	737·	160·	9·5	2	230·
Vixen	160·	754·	160·	9·	2	230·
Waterwitch	162·	778·	160·	9·2	2	230·

11 Turret and Special Vessels.

1st Class, 2 *Vessels.*

Name.	Length in feet.	Tonnage.	H. P.	Speed.	No. of Guns.	Weight of Broadside in lbs.
Thunderer	285·	4400·	800·	12·5	4	2400·
Devastation	285·	4400·	800·	12·5	4	2400·
2nd Class, 2 *Vessels.*						
Monarch	330·	5102·	1100·	14·9	6	2515·
Captain	320·	4272·	900·	14·2	6	2515·
3rd Class, 1 *Vessel.*						
Hotspur	235·	2637·	600·	12·0	1	600·
4th Class, 2 *Vessels.*						
Glatton.....	245·	2709·	500·	9·5	2	1200·
Rupert.....	250·	3159·	700·	12·	2	1200·
5th Class, 2 *Vessels.*						
Royal Sovereign	240·	3765·	800·	11·	5	1250·
Prince Albert	240·	2529·	500·	11·6	4	1000·
6th Class, 2 *Vessels.*						
Scorpion	224·	1833·	350·	10·5	4	1000·
Wyvern	224·	1899·	350·	10·	4	1000·

According to which, we have no less than thirteen classes in a collection of merely 47 ironclads.

It is difficult to imagine on what principle this classification was made, or what object was gained in making it, save that of showing us what a curious collection we possessed; when, to become aware of our errors and mistakes, should have formed the first step towards rectifying them for the future.

Not being able to see from the above classification of our ironclads in what way the requirements of our Navy have been fulfilled as a fleet, I have rearranged and classed them, as nearly as possible, in accordance with their maximum average speeds under steam, and in the order of their birth, as follows:—

Table B.

Classed for Uniform Maximum Speeds.

1st Class. 14 *Knots.* 11 *Vessels.*

Name.	Length in feet.	Tonnage.	H. P.	Speed.	No. of Guns.	Weight of Broadside in lbs.
Warrior	380·	6109·	1250·	14·3	32	1970·
Black Prince	380·	6109·	1250·	14·0	32	1970·
Achilles	380·	6121·	1250·	14·3	26	1765·
Agincourt	400·	6621·	1350·	14·4	26	2150·
Northumberland	400·	6621·	1350·	14·4	26	2150·
Minotaur	400·	6621·	1350·	14·4	26	2150·
Bellerophon	300·	4270·	1000·	14·1	18	1600·
Hercules	325·	5234·	1200·	14·6	12	2080·
Monarch	330·	5102·	1100·	14·9	6	2515·
Sultan	325·	5226·	1200·	14·6	12	2080·
Captain	320·	4272·	900·	14·2	6	2515·

2nd Class. 13 *Knots.* 8 *Vessels.*

Audacious	280·	3774·	800·	13·5	10	1250·
Invincible	280·	3774·	800·	13·5	10	1250·
Vanguard	280·	3774·	800·	13·5	10	1250·
Iron Duke	280·	3774·	800·	13·5	10	1250·
Triumph	280·	3893·	800·	13·5	10	1250·
Swiftsure	280·	3893·	800·	13·5	10	1250·
Lord Clyde	280·	4067·	1000·	13·4	20	1300·
Lord Warden	280·	4080·	1000·	13·4	24	1400·

3rd Class. 12 *Knots.* 13 *Vessels.*

Hector	280·	4089·	800·	12·3	18	1100·
Valiant	280·	4063·	800·	12·6	18	1100·
Ocean	273·	4047·	1000·	12·8	24	1510·
Caledonia	273·	4125·	1000·	13·0	24	1510·
Prince Consort	273·	4045·	1000·	13·1	24	1510·
Royal Oak	273·	4056·	800·	12·5	24	1510·
Royal Alfred	273·	4068·	800·	12·3	12	1530·
Resistance	280·	3710·	600·	11·8	16	985·
Defence	280·	3720·	600·	11·6	16	985·
Zealous	252·	3716·	800·	12·4	10	565·
Repulse	252·	3749·	800·	12·4	12	1360·
Pallas	225·	3372·	600·	12·4	8	464·
Penelope	266·	3096·	600·	12·7	11	1080·

Various. 13 *Vessels.*

Name.	Length in feet.	Tonnage.	H. P.	Speed.	No. of Guns.	Weight of Broadside in lbs.
Royal Sovereign	240·	3765·	800·	11·0	5	1250·
Prince Albert	240·	2529·	500·	11·6	4	1000·
Enterprise	180·	993·	160·	9·9	4	230·
Favorite	225·	2094·	400·	11·8	8	524·
Research	195·	1253·	200·	10·3	4	230·
Viper	160·	737·	160·	9·5	2	230·
Vixen	160·	754·	160·	9·0	2	230·
Waterwitch	162·	778·	160·	9·2	2	230·
Glatton	245·	2709·	500·	9·5	2	1200·
Hotspur	235·	2367·	600·	12·0	1	600·
Rupert	250·	3159·	700·	12·0	2	1200·
Wyvern	224·	1899·	350·	10·0	4	1200·
Scorpion	224·	1833·	350·	10·5	4	1200·
Thunderer	285·	4400·	800·	12·5	4	2400·
Devastation	285·	4400·	800·	12·5	4	2400·
Fury.....	.. ..	5000·	1·000	13·5	4	2400·

Now, although we may arrange our ocean-going ironclads in accordance with their speeds into three classes, such an arrangement omits from its consideration many important points. The first is, they are not fitted with uniform proportionate rudder-power; some possess large rudders and great power of command, while others, on the contrary, possess small rudders, with inefficient power of command; but this, fortunately, is remediable at a small cost, and in very little time. Not so, however, as to other vital matters. For instance, they are incapable of being combined for evolutions under sail alone; the sail equipments being so various and peculiar, and comprising almost as many fashions as a lady's toilet. Again, the offensive and defensive powers are equally various and unsatisfactory.

Some people, however, appear to believe that this very variety, in a general action, "would be the cause of the greatest possible embarrass-"ment to the enemy." I am not aware that such a notion is entertained by any Naval Officer; and by a parity of imagination, a troop of soldiers variously armed and mounted, say on camels, elephants, and Jerusalem ponies, should also "be the cause of the greatest embarrassment to "the enemy." Such a medley would certainly not embarrass, but might puzzle and amuse, and would prove but as chaff before the wind against a troop of cavalry uniformly equipped and mounted. The notion that such variety is of advantage is simply ridiculous, and as ridiculous for the Navy as for the Army.

No principle appears to me to have been followed in the production of our recent ironclads, towards the realization of an efficient and

uniform ironclad Navy. In fact, had variety been the object sought, and one or two millions of money been annually devoted, simply for the purpose of exercising ingenuity in the production of crude and fanciful ironclads, we might have been fully satisfied with the success obtained in this respect. Such, however, is not the purpose for which the heavily-pressed taxpayers of this country are called on to subscribe their money, but for our national insurance policy, the maintaining of the honour and glory of this great empire, and the protection of vital commercial interests, *efficiently* and *economically*.

Having briefly considered our ironclads collectively, let us now consider them individually.

In the early days of ironclads, the 68- and 100-pounders were what may be termed the guns of the day, that is, the most powerful then made. Subsequently the 300-pounders; and at the present time the 600-pounder is supposed to be the most powerful gun.

It would be tedious to refer to the peculiarities of all our ironclads. Let us therefore take one or two of the different types produced at the several epochs of the guns, the 100-pounder, the 300-pounder, and the 600-pounder.

We may take the "Warrior" or "Achilles," as representing the 100-pounder era.

The "Bellerophon," "Hercules," and "Audacious," as representing the 300-pounder era, and

The "Monarch" and "Captain" the 600-pounder era.

The "Devastation type" not being ocean-going, we will here exclude, for special consideration presently.

"WARRIOR" AND "ACHILLES."—The "Warrior" and "Achilles," laid down in 1859 and 1860, were designed to be armed with, and armoured to resist, the heaviest guns of their day. The "Achilles" differs from the "Warrior" simply in having a greater midship section and displacement, and having the armour extending all round the ship to the height of the main deck, otherwise their general dimensions and horse-power are identical.

The steaming powers of the "Achilles," under all circumstances, are the highest and most economical yet attained by any ironclad, but her manœuvring powers are very limited, owing to the absurdly small and inefficient rudder with which she is fitted, being 130 per cent. less than that of "Bellerophon," although a much longer and larger ship.

The sailing powers of the "Achilles" stand very high, but I cannot here refrain from alluding to the freaks and fancies practised in the masting and rigging of this ship. She was originally designed for three masts, as the "Warrior." She was then altered for and fitted with four masts, under which fanciful arrangement of sails she was comparatively *nowhere*, and ultimately, at considerable expense, she was altered back again to three masts, as at present. If there were no proper and acknowledged rules for providing the amount and positions of the several sets of sails—and experience on such matters were altogether wanting—there would have been some justification for the alterations, and they would have been experiments worth the money; but I cannot

understand on what principle it was done, and, moreover, the absurdity was further exaggerated in three subsequent vessels, by giving five masts, although they were designed to carry but three. The alterations entailed considerable outlay, and the latest recommendations of our Admirals respecting them is, that they should be altered back again to three masts, which will involve additional and very great expense.

The "Achilles," it is well known, possesses the most steady gun-platform; and would, if fitted with a proper rudder, take her place at the head of all our iron-clads, except only in offensive and defensive powers.

The "Bellerophon" was laid down in 1863, and the "Hercules" in 1865.

The peculiarities of the "Bellerophon" are so well known that I may pass her by with a few remarks:—

She is armed with 250-pounders, and her armour, although less in extent than in the "Achilles," is slightly thicker, and is, I believe, calculated to resist projectiles from similar guns to her own.

The speed of the "Bellerophon" under all circumstances is very inferior to that of the "Warrior" and the "Achilles." I may be told that the "Bellerophon" equalled the "Warrior" on a series of "six hours' trials at sea," but on this point I have my doubts, and I should further like to ask why were not the trials made by the "Warrior," "Bellerophon," and "Minotaur" at the same time and under the same circumstances?*

The manœuvering powers of the "Bellerophon" are very great, owing to her large balanced-rudder, yet she does not sail well, which may perhaps be accounted for in part by her balanced rudder, and that monstrosity—her *plough-bow*.

Although carrying 250-pounders and proportionately good defensive powers, she cannot be considered an improvement on the "Achilles," on the contrary, she is inferior in every other respect.

"Hercules."—The "Hercules" may be considered an improved "Bellerophon;" in her notably, the plough-bow has been discarded, and I need hardly say with advantage. She is armed with 400-pounders, 18-ton guns at the broadside, in a central *box* or battery pierced with 12 portholes.

Her defensive powers are far from being satisfactory, for although at about the water line, they are fully capable of resisting projectiles from similar guns to her own, yet the 'tween decks and the fighting battery are comparatively weak, especially the ends of the battery, which are merely protected with 5 inches of armour on 10 inches of teak.

The "Hercules," as regards standard of merit for form and speed, is greatly inferior to "Achilles"—thus—

* The "Minotaur" was tried on the 18th March, the "Warrior" on the 3rd April, and "Bellerophon" on the 2nd May, 1868. The alleged speeds on those occasions were estimated from the number of revolutions of the engines, and are not their actual performances. (See Parl. Return 283, May, 1868.)

	"Hercules."	"Achilles."
Displacement	8676·	9487·
Indicated H. P.	8529·	5722·
Speed	14·69	14·32
Standard of Merit	156·9	230·1

Thus showing that in this particular, instead of progression, retrogression has taken place.

"AUDACIOUS" CLASS.—The first vessels of the "Audacious" class, of which six are now building, were laid down in 1866 and 1867, notwithstanding that in 1865, Captain Coles had clearly shown, that 600-pounders could be efficiently carried in a sea-going ironclad of about 1,000 tons less burden with the same speed.

The building of these six vessels appears to have been the only attempt, if attempt it was, at uniformity; yet it is simply, in my opinion, an uniformity of inferiority. They are of a new fashion, but why six were laid down, before one had been tried, it is difficult to say.

The guns of this class are 250-pounders, six on the main deck in a "box," and four on the upper deck in *half a box*.

The defensive powers are altogether of a very inferior character, for although a small portion of the hull is protected at the water-line with 8 inches of armour, the other portions are only protected with 6 inches, 5 inches, and 4 inches of armour; but the weakest point of all is the deck, which being even with the top of the armoured belt, and but 4 feet above the water, is merely protected with $3\frac{1}{2}$ inches of wood, and a thin steel plating of only $\frac{5}{16}$ of an inch for deflecting shot: almost any shot fired at about 7° depression would certainly penetrate and probably sink the ship. The remark made by the Controller of the Navy before the Turret-ship Committee, applies with double force to these six vessels. He stated that "a shot may come in at the top of "the armour on one side, and go right through and strike the armour "on the opposite side; and we have every reason to believe from "experiments made, that it would drive the armour-plate off, and "might destroy the ship."

In this respect the "Penelope" is even worse than the "Audacious," for her belt is but 18 inches above the water.

It is really incomprehensible how it happens that a defect pointed out in such clear language in 1865, should subsequently in 1866 be simply exaggerated and further perpetuated in six new ships, none of which have yet been tried, and most of which are still on the stocks.

Their speed, estimated only at $13\frac{1}{2}$ knots, is a retrograde step, and cannot be excused in these days of progress in the steam-ship speeds of the mercantile marine, and the high economical speeds of our earliest iron-clads.

"MONARCH."—The "Monarch" was laid down in 1866, the "Cap-"tain" in 1867.

The "Monarch" is the first real attempt to build a sea-going turret-ship by the Admiralty, and although laid down after the "Hercules," and designed to carry more powerful guns, yet her defensive powers are less than the maximum of "Hercules" at load-water line.

It is deplorable to think of the admitted fact that it was only in 1868 that those intrusted with the construction of our ships should have become alive to the self-evident principle that "armour, if carried at all, should be able to resist the artillery it was likely to meet." Yet we have seen that in our earlier iron-clads this principle was fully recognized, and appears only to have been disregarded in our later ironclads, and to a greater extent than ever in the "Monarch;"—her defensive powers being totally inadequate to resist similar projectiles to her own.

It has been stated in another place that "by universal consent the "'Monarch' is one of the most efficient ships." This may be so, but the real question is, is it *the most efficient* and *most economical* ship that can be produced?

The "Monarch," it is well known, is in America, and I understand that a commission, composed of Naval Officers, was appointed by the Secretary of the United States Navy to examine and report on her, and they have reported that, "apart from her excellent steam "machinery, and beyond the execution of the work itself as an iron "ship, there is no point in the *design* of the 'Monarch' worth our "notice."*

"CAPTAIN."—In the spring of the year 1866 the great question of the adoption of the turret-system for our future Navy was prominently before the public, and in consequence of the many discussions on the subject, both in and out of Parliament, it was decided by the Admiralty to afford to Captain Coles an opportunity of carrying out his views as to what an efficient sea-going cruiser on the turret principle should be. He was by the Admiralty instructed to select from a limited list of shipbuilders a firm with whom he would be disposed to enter into the question, and prepare a design to be submitted to their Lordships.

Looking to the fact that Messrs. Laird had at that time considerable experience in the designing and building of turret ships for foreign governments, and to their reputation as builders, he selected their firm as the one with whom he would wish to work.

The general outline of requirements having been agreed upon with the Admiralty, Messrs. Laird, in conjunction with Captain Coles, prepared a design and specification of a ship to compete with the "Bellerophon," which design was submitted to the Admiralty in July, 1866, as representing the type of vessel suited to carry out the object in view. This design was approved, and in February, 1867, a contract was entered into for her construction.

The principal dimensions of the "Bellerophon" and "Captain" are as follows:—

* The report is signed by Captain Lenthall and Captain King of the United States Navy.—C. F. H.

	"Bellerophon."	"Captain."
Length	300 ft.	320 ft.
Breadth	56 ft.	53 ft. 3 in.
Draught forward	22 ft. 7 in.	24 ft. 3 in.
Draught aft	26 ft. 5 in.	25 ft. 6 in.
Horse Power	1,000	900
Tonnage	4,270	4,272
Weight of Broadside	1,600	2,515
Speed	14·1	14·23

The hull of the "Captain" is wholly protected by armour from 6 feet 6 inches below the water-line to the upper deck, which is 6 feet 6½ inches above the load-water line, thus affording complete protection, not only to the midship part of the ship, where the machinery and turrets are placed, but also to the quarters for officers and men. The thickness of armour opposite the turrets is eight inches, and on the remainder of the midship portion seven inches, slightly reduced towards the ends. These plates rest on a backing of East India teak 12 inches thick, through which they are bolted to the skin of the ship, which is 1½ inches thick (formed of two ¾ inch plates), the whole supported by massive framework 10 inches deep. This backing is further supported by longitudinal girders 10 inches deep. The upper deck at the level of the top of the armour is covered with iron 1½ inches thick for the length of the turret spaces, and with 1 inch over the remainder, supported by iron beams 14 inches deep, and covered with teak 6 inches thick.

The general construction of the hull of the ship is similar to that of other large armour-clad ships built for Her Majesty's Navy, and combines a complete arrangement of water-tight double bottom, wing passage, and other bulkheads. The fore-end especially is made of enormous strength, and terminates in a massive wrought-iron stem, formed as a ram for running into an enemy's ship. The armament is to consist of six guns, four of which are to be carried in the turrets and two on the upper deck. The guns in the turrets are to be 600-pounder 25-ton guns; those on the upper deck, at the fore and after end, are to be 100-pounder 6½-ton chase guns. The turrets, two in number, each carrying two 600-pounder 25-ton guns, project through circular openings in the upper deck. That part exposed to shot is covered with armour-plates 10 inches thick about the ports and for one-third the circumference, and with plates 9 inches thick for the remainder; while the lower part and all the gearing is protected by the 8-inch armour on the sides of the hull. The height of the guns is 10 feet above the water-line, which will admit of them being fought at sea in very heavy weather, and they will have an arc of training from the foremost turret of 150°, and from the after turret of 150°. The turrets are each 27 feet external, and 22 feet 6 inches internal diameter.

The recent successful trials of speed at the measured mile cannot but be a matter of great satisfaction not only to Captain Coles and the Messrs. Laird, but also to the Navy and to the country generally.

Although not designed to compete with the "Hercules" or "Monarch," which are larger vessels with more powerful engines, it will not be uninteresting to compare the "Captain" with them.

	"Hercules."	"Monarch."	"Captain."
Length	325 ft.	330 ft.	320 ft.
Breadth	59 ft.	57½ ft.	53¼ ft.
Displacement	8,530 tons.	8,164 tons.	7,650 tons.
H. P. nominal	1,200	1,100	900
Speed in Knots	14·69	14·9	14·32
Number and Calibre of Guns	8—400 prs. 2—250 prs. 2—115 prs.	4—600 prs. 2—115 prs.	4—600 prs. 2—115 prs.
Weight of Broadside	2,080 lbs.	2,515 lbs.	2,515 lbs.
Tonnage	5,234	5,102	4,272

The extreme simplicity of the turret-system puts all the ingenious devices for working heavy guns on the broadside completely in the shade; for not only does it afford far better protection for the ship and the men who fight the guns, but the guns and carriages require the least possible amount of gear to work them, and that, too, of the simplest description. The most simple is invariably the most effective.

Assuming the seagoing qualities of the "Hercules," "Monarch," and "Captain" to be on a par, and taking the cost of ship at £60 per ton, and the engines at £65 per horse, we see that the "Captain" would cost £62,800 less than "Monarch," and £77,220 less than "Hercules."

The "Captain," therefore, takes her place at the head of all our present sea-going iron-clads as the most powerful, and at the same time the most economical; and it is to a private ship-building firm, in conjunction with Captain Coles, that the country is indebted for this highly satisfactory result.

Construction.—The structural arrangements of our latest ironclads do not vary very considerably from those which preceded them; the principal improvements consist in giving them a more complete double bottom, and in lightening the weight of the hull. For instance, the hull of the "Minotaur"* was made comparatively lighter than that of "Achilles," although a much larger ship, and in subsequent ships, the hulls have been made comparatively lighter still, and simplified in the details of their construction. Such improvements constantly occur in private yards, and it is only reasonable to expect that the Admiralty should not, in such matters, be behind the private shipbuilder, more especially as the Admiralty have the means of acquiring all the latest improvements introduced in almost every private yard in the Kingdom.

Long and Short Ironclads.—We may now briefly allude to the subject of "long and short ironclads."

I am not aware that it has ever been stated that the number of merit derived from the formula $\frac{\text{speed}^{\,3} \times \text{disp.}^{\,\frac{2}{3}}}{\text{indicated H.-P.}}$ should form the *sole*

* The "Minotaur" is even superior in this respect to the later designed "Bellerophon," thus:—

	Weight of Hull.	Weights Carried.
"Minotaur"	5,043 tons.	5,232 tons.
"Bellerophon"	3,652 „	3,798 „

standard by which to judge of our ironclads. And no doubt, if such an erroneous idea were entertained, and carried out in its entirety, it would lead to the construction of ships that would carry no weights except those of the propelling apparatus, but obviously, if the converse, or what has been termed the short ship theory, were carried out in its entirety, it would lead to the construction of ships as broad as they were long, capable of going as fast sideways as endways.

Figs. 1 and 2, plate XIV, represent these two extreme cases; both ships are of the same displacement, the short ship is as long as she is broad, and the long ship is twenty times her breadth of beam, the draught of water being the same in both cases.

Now if both such vessels were fitted with equally powerful engines, it is evident that the long ship would beat the short ship, and it is no answer to the objections which have been urged against short, badly formed ironclads, to say that it is not the function of the ship to propel her engines, but to be propelled by them at a speed exactly proportioned to the power exerted, for this is simply a begging of the whole question as to what is the exactly proportioned power; or if it means anything else, it means that this short ship might be filled with steam power, but *she* would in that case carry nothing but her propelling apparatus, and even assuming that the short might in that case equal the long ship in speed in *smooth water*, she certainly would not in a sea-way.

Is it not evident that the "desideratum" is a mean between the extremes? for the obtaining of which there is no better method than the above-mentioned formula.

It has been stated—but on what grounds it is difficult to conceive—that a saving has been effected by the introduction of what are called short ironclads, in place of the long and costly ironclads which preceded them, at the rate of £100,000 per ship, and that many such ships have been built. Now, I will ask any gentleman to look at the list of our ironclads on page 152, and in order that some idea may be formed as to the true facts of the case, it will be only necessary for me to give you the cost of two or three ships; and the figures I shall quote, will not, I think, be questioned.

	"Warrior."	"Hector."	"Bellerophon."
When built	1859	1861	1863
By whom built	Private firm.	Private firm.	Admiralty.
Length	380 feet	280 feet	300 feet
Tonnage	6,109	4,089	4,270
Displacement	9,020	6,409	7,450
Horse-power	1,250	800	1,000
Cost	£385,188	£299,050	£398,736

Thus we see that the "Bellerophon" is 20 feet longer and 200 horse-power greater, and costs just £100,000 more than the "Hector," and although the "Bellerophon" is 80 feet shorter and 250 horse-power less than the "Warrior," she actually costs £13,500 more. Where,

SECTI

Fig. 3.

"DUNCAN"
CONVERTED.

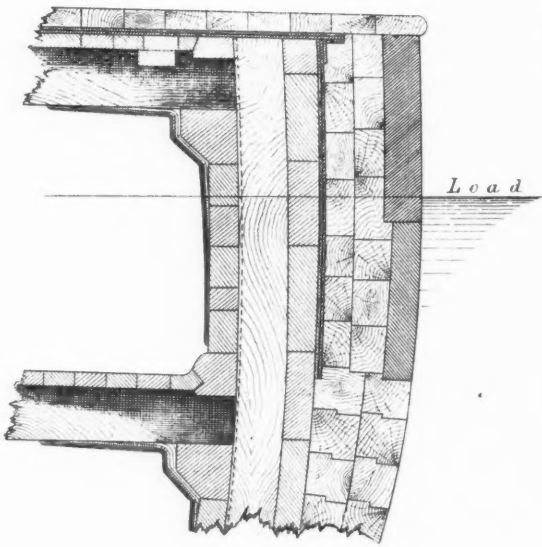


Fig. 5

"DEVASTATI
"THUNDERE
AND "FUR

LONG SHIP.

Fig. 1.

CTIONS.

Fig. 5.

EVASTATION"
THUNDERER"
ND "FURY"

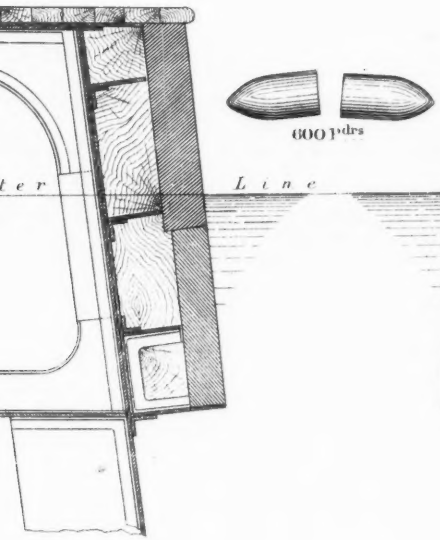
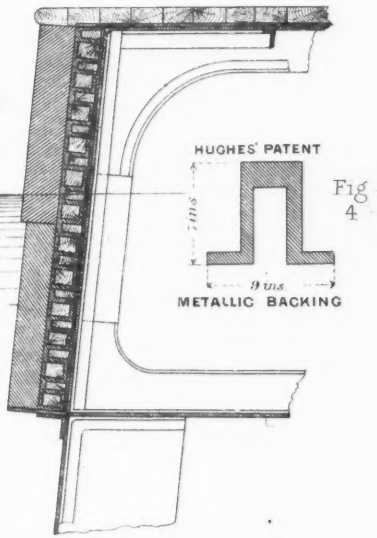


Fig. 6.

SAME WEIGHT AS "DEVASTATION"
BUT STRONGER AND CHEAPER.



SHORT SHIP.

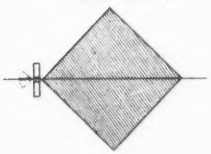


Fig. 2..

J.Jobbins

then, is the saving on even one of the recent short ships, where therefore on the many? Echo answers—where?

It is not in the "Bellerophon," that is clear. Is it in the "Lord Clyde?" "Lord-Warden?" "Pallas?" "Hercules?" "Penelope?" "Repulse?" or "Monarch?" The fact is, there has been no such saving, but on the contrary, the public money has been recklessly squandered during the last five or six years. For example.

What can be said of such vessels as the "Vixen," which, on attempting to go from one port to another in this country proved totally unseaworthy, rolling 50 degrees, it is said, each way, though there was not, what seamen would call, "a gale of wind," and the crew went aft in a body and protested against being sent to sea in such unseaworthy vessels. These might, with advantage to the country, form the first instalment for what was lately suggested by a gallant Naval Officer would be the probable fate of, and most economical use for, most of our present ironclads, viz., to be melted down and drawn out into telegraph wires.

It has been found convenient by some persons to suppose or insinuate that had the designers of our earlier ironclads continued in office they would, with the advance made in the power and weight of the guns and the consequent increase of thickness in the armour, have simply increased their size and cost, instead of reducing the area to be protected, as has been the case in what are called "box" ships.

I may be permitted unhesitatingly to state, that had those designers continued in office they would long ago have given the country a Turret Navy, and thereby have saved millions of money.

"DEVASTATION" and "THUNDERER."—These have hitherto been excluded from consideration, as they are novelties, and expensive novelties too, and require special attention.

It is stated that the object of the Admiralty "in building these "ships has been to produce war ships of great offensive and defensive "powers, well adapted for Naval warfare in Europe.

"The *Offensive Powers* have been regulated by the desire to fur- "nish these ships with guns which would penetrate the armour of the "ironclads of Europe, with few or no exceptions; to give to them full "and uninterrupted command in all directions; and to so place and "work them that they may be efficiently and securely worked in a "seaway under all but the most extreme circumstances.

"The *Defensive Powers* have been regulated by the desire to make "the ship practically secure against destruction by shot or shell in a "Naval engagement for many years to come, and to give her a fair "degree of security in attacking land fortifications."

It is further stated that the defensive powers of these vessels have been designed to resist the artillery they are likely to meet.

In these days of invention and improvement, the building of new ironclads becomes a very serious question. The experience of the past few years clearly indicates that we may reasonably expect great and radical changes in the course of the next few years, not only in the steam-engine—the means of generating steam—and the mode of propulsion; but with the wonderful improvements effected by Messrs.

Bessemer and Sir Joseph Whitworth in the manufacture and production of metal—guns of 50 tons weight, throwing projectiles of 1,000 pounds, will inevitably be produced even before the "Devastation" and "Thunderer" are completed. Of what use, then, will these vessels be against 1,000 pounders if only capable of resisting 600 pounders?

Then, too, we must consider the comparatively enormous cost of these vessels, amounting, with the "Fury" just ordered, to not much less than £1,000,000 sterling, an immense sum to lay out for three such purely experimental vessels, when, in another and a simpler way, we might obtain three vessels, practically as good, at one-third the cost, and in one-third the time.

Last session I had the honour of bringing before the members of this Institution the subject of the "conversion of line-of-battle ships into sea-going monitors." On that occasion the model of the "Duncan"* so converted, was exhibited.

Now it will be obvious, that by dispensing with the masts, yards and sails, a large portion of the crew, stores, and equipments, considerable weight is saved, which, together with the weight of the spar-deck and the centre turret, may be readily converted into additional armour-plating. The result of such modification is given in the following table, with similar particulars of the "Devastation."

The breastwork-system, I may mention, was proposed by Captain Coles in 1865.

	Breastwork Monitors.	
	"Duncan."	"Devastation."
Length	252 feet	285 feet
Breadth, extreme	63 „	62 ft. 3 in.
Draught forward	25 ft. 1½ in.	25 ft. 9 in.
Do. aft	25 ft. 4½ in.	26 ft. 6 in.
Tonnage	3,727	4,400
Horse-power	800	800
Speed in knots	12½	12½
Armament	4 600-prs.	4 600-prs.
Weight of broadside	2,400 lbs.	2,400 lbs.
Height of monitor deck	4 ft. 0½ in.	4 ft. 6 in.
Height of guns	13 „	13 ft. 6 in.
Complement, Officers and crew	250	250

The defensive powers of the "Devastation" are equivalent to 15¾ inches of solid iron, those of the "Duncan" equivalent to 15½ inches. (See Plate, figs. 3 and 5.)

Now obviously if our Navy were in a satisfactory condition, it would be wise to suspend building any more ironclads for the present.

That our Navy is not in a satisfactory condition is clearly

* This model, with that of the "Duncan" as a 90 gun screw line-of-battle ship, are in the Museum of the Institution.

admitted, and the necessity for increasing its strength acknowledged, in the speech of the First Lord of the Admiralty in the House of Commons last Monday evening—"We have come to the conclusion "(said the right hon. gentleman), having regard to the present state "of the Navy, and to the point at which it should be kept up, that we "should annually build 20,000 tons of shipping, of these 12,000 tons "being armoured."

Under all these circumstances, can it be considered a wise economy to lay out nearly £1,000,000 for that which we may obtain, practically as good, in another way, for about one-third this amount?

In building the "Fury," another variety will be added to our already varied collection. She is to be an *improved* "Devastation," the improvements consisting in her being 600 tons larger, 200 horse-power greater, with a speed of 13½ knots, and carrying 50 additional men and 100 tons more coal. The *offensive and defensive powers* remaining the same as in the "Devastation" and "Thunderer."

Although 13½ knots is undoubtedly an improvement on 12½ knots, yet it is inferior to the speeds of our earliest ironclads, and it would be wiser to pay a little more money and obtain 14½ knots; such speeds being regularly maintained by our Transatlantic steam ships. It would be especially desirable, inasmuch as the second vessel of this class is not commenced, that she should be reconstructed, and at the least made of equal speed to the "Fury," viz., 13½ knots.

The axiom that the offensive and defensive powers should be equal, or in other words, that the defensive powers should be equal to resisting the projectiles likely to be met with, cannot be disputed.

Let us now enquire whether the defensive powers of these latest ironclads do fulfil this condition.

Although it may be true that the strength of armour-plates increases as the square of the thickness, for plates up to 6 inches or 8 inches in thickness, it is not true of armour-plates of 12 or 15 inches thick; for it is not possible with the metal and the means of manufacture we possess at the present time, to produce 12 or 15 inch plates of proportionate resisting power to the 6 or 8-inch plates. I may mention that there is a 15-inch armour-plate at Shoeburyness, which was broken up like so much gingerbread by the Rodman 450-pounder spherical shot. Again, the question arises, is teak the best backing for the armour of a ship? Experiments have clearly shown that it is not, and it is obvious that although it might have been a sufficient backing for 4½-inches of armour, for resisting the 68-pounder spherical shot, there is no reason for supposing that it would afford proportionately efficient backing for 12 inches of armour for resisting the 600-pounder Palliser shot. Some such considerations led my friend Mr. John Hughes, whose experience in the manufacture of iron and armour-plates, and in the construction of armour-plated defensive works, is probably not surpassed by that of any one, to bring his mind to bear on the subject; the result has been the production of what is termed "*Hughes's Patent Metal Backing.*" (See fig. 4.)

You will observe that it resembles an immense bridge-rail, but of such a size that it was considered by eminent engineers and manufac-

turers at the time, impossible to manufacture such a section; but not only did Mr. Hughes succeed in making this section of 7 inches in depth, but with the same machinery he is prepared to manufacture similar sections up to 12 inches in depth.

Permit me now, to briefly illustrate a few experiments which were made to test, in a rough way, the comparative efficiency of this "metal backing."

A piece of this 7-inch "metal backing" was taken, 24 inches in length and riveted to two one-inch plates, and placed on two bars at the underside near to the extremities, with a third bar on the top. A heavy weight (of 1,512 lbs.) was then let fall from a height of 33 feet, five times; pieces of armour plate of the same length and width, and of 4 to 5 and 6 inches thick respectively, were subsequently similarly experimented on. The results are recorded in the following table, in sixteenths of an inch:—

Blows.	Deflection.			
	7-inch Metal Backing.	4 inches Armour.	5 inches Armour.	6 inches Armour.
First	2·	6·	4·	2·
Second	4·	15·	9·	4·
Third.....	6·	20·	13·	6·
Fourth	9·	28·	17·	8· full
Fifth.....	10·	32·	20·	10·

Thus you see that the 7-inch metal backing was equivalent to 6 inches of solid armour plate.

These results were practically corroborated by the results of the firing at Shoeburyness, at an embrasure made at Millwall for the War Department, and generally known as the "Millwall Shield," in the construction of which this "*metal backing*" was very largely employed.

The following comparison of the weight and cost shows a saving of 33 per cent. in weight and 54 per cent. in cost:—

1 s.f. of 6-inch plate = 240 lbs. at £34 per ton	£3	12 10
1 do. of 7-inch metal backing „ 2-inch plates } = 160 lbs at £18 per ton ..	1	5 9
	£2	7 1

Let us now apply this experience gained to the defensive powers of such a vessel as the "Devastation," so as to obtain the same weight. (See Plate, Figs. 5 and 6):—

Assuming one square foot of the 12-inch armour to weigh 480 lbs., the 18 inches of teak backing with longitudinal stringers to weigh 75 lbs., and the two inner skins to weigh 60 lbs., we have a total of 615 lbs. as the weight of one square foot of the minimum defensive powers of "Devastation."

On the other hand we have 10 inches of armour equal to 400 lbs., the 7-inch "metal backing" with teak filling and in-filling and 1-inch intermediate plates, equal 131 lbs.; the two 1-inch skins equal 80 lbs., giving a total weight of 611 lbs., rather under that of "Devastation."

Again, assuming the resisting power of teak to be one-eighth that of iron, we have as follows :—

	Devastation, as building.		Do. with Hughes's Metal Backing.	
Armour.....	12 ins.	= 12 ins.	10 ins.	= 10 ins.
Backing.....	18	= 2¼	7	
Skins.....	1½	= 1½	2	= 6
		15¾ ins.		16 ins.

but obviously by the addition of the intermediate teak, and 1″ iron plates, the strength of the backing is considerably increased.

Another and very important point gained is that by the aid of this "metal backing," the defensive powers are not only increased, but they are incorporated with, and enormously increase the strength of the ship herself for ramming.

Thus it is clearly shown that efficiency and economy have been disregarded in our most recent iron-clads, and their low speeds (12½ knots estimated) are already condemned by the authorities themselves, even before the second vessel is laid down, by proposing a greater speed for the third (viz., 13½ knots estimated).

In this part of my subject my object has been to show—

1st. That our present collection of ironclads do not fulfil the requirements of a Fleet for uniform maximum combined operations.

2nd. That no recent progress has been made towards fulfilling such requirements; for even the latest addition merely makes confusion worse confounded.

3rdly. That whatever progress has been made in the individual character of our recent ships, the credit of such progress rests rather with the private shipbuilder than with the Admiralty.

Lastly. That there does not appear to be one single vessel which may form a suitable type on which to found a specific and efficient class.

Thus fully bearing out those words of solemn warning uttered in Parliament by an experienced and practical Naval Officer, that "if "the present faulty and retrograde system be persisted in, it will in- "evitably lead to the disgrace of the Navy of England, and the humi- "liation of this great nation."

Future Ironclads.—The second part of my subject treats of future ironclads, and opens up a very large question.

In considering this subject, and in endeavouring to indicate what our future ironclads should be, I have availed myself of the published opinions and experience of practical Naval Officers and others; of these permit me to quote one or two in illustration.

Sir William Fairbairn states:—"It is essential that the steam Navy

"of this country should have great command of power, to enable the "ships to manœuvre at sea with the precision of a squadron on "parade."

Admiral The Right Honourable the Earl of Hardwicke, speaking of the probable future (the next 25 years), says:—"Ships will be pro- "pelled by steam, that there is no doubt of; the form of propulsion "will be the turbine; the vessels will be full rigged, and the armour- "plating will be very much reduced—not left off, but reduced."

Admiral Sir Edward Belcher says:—"My own ideas lead me to in- "sist on their being made good lively sea-boats; capable primarily, "under spars and canvas, of holding a good wind, and being as "trustworthy, under any conditions, on a lee-shore, as if they had no "machinery on board, or had been disabled."

Captain Selwyn says:—"If you do not give us the highest speed "attainable by any man-of-war afloat in the world, you have taken "from us the power of catching that man-of-war when we see her; "and practically, whether your ships cost £1,000, or £10,000, or "£1,000,000, if they cannot do the work they are sent out to do, "you had better have spared your whole money, as the best way of "doing nothing."

"All we ask (says Sir E. Belcher) is, furnish us with tools fit to "execute the work, and leave us to perform our duty."

The first questions that arise are, into how few classes should our future ironclad Navy be divided, and the individual character of each class?

These naturally lead to the further inquiry, what *are* the require- ments of a Navy for this great maritime power?*

Primarily, we must protect our coasts for (as it has been well said), to be safe at home is the best preparation for making, if necessary, an offensive movement abroad.

Secondly, we must possess, if I may use the term, our army of the seas, *i.e.*, our line-of-battle ships, to enable us to make, if nccessary, an offensive movement abroad.

And thirdly, we must possess fast vessels for the protection of our valuable commerce.†

It would obviously be an error to create a special class, unless essentially necessary. We may, therefore, consider, until it is shown to the contrary, that three classes would suffice, viz., Coast-defence- ships; Line-of-battle-ships; and ships for the protection of our com- merce.

In considering the characteristics of each of these classes, the pro- positions advanced by Admiral Halsted, will, I think, aid us. They are as follows:—

1st. "As in past battles between fleets of wood, so in future fights

* In considering this matter, it will be well to bear in mind that the area of the United Kingdom is but about one-thirtieth of the total area of the Empire, and its population but about one-fifth.

† Our floating commerce represents about £500,000,000, and if our maritime trade were stopped for a single month, it would represent a loss of at least forty millions sterling.

"between ironclads, the respective projectiles must determine the "issue of victory or defeat."

2nd. "The respective projectiles must determine this issue according "to their excellence in material, proportions, form, range, accuracy, "penetration, and explosive force."

3rdly. "These requisite conditions of excellence in the projectiles "must govern the conditions for the gun."

4thly. "The requisite conditions for the guns must govern the "mode of ship best able to carry and fight them."

Now, it may be reasonably assumed that the weight of the future projectiles will be of 1,000 lbs. at least, and the weight of gun about 50 tons.*

With this 1,000-pounder, then, as a unit or starting point, and taking into consideration and carrying out as far as practicable the propositions and opinions above mentioned, the following results are produced and placed in a tabulated form :—

PROPOSED FUTURE IRONCLAD NAVY—THREE CLASSES.

	Coast-Defence.	Line-of-Battle.	Protection of Commerce.
Projectiles, primary	1,000 lbs.	1,000 lbs.	1,000 lbs.
Number of guns for ditto	4	4	1
Gun carriages	Two double barrelled turrets.	Two double barrelled turrets.	One turntable.
Projectiles, supplemental	150 lbs.	150 lbs.	150 lbs.
Number of guns for ditto	8	8	10
Steadiness at sea to equal "Achilles."			
Weight of combined broadside	4,600 lbs.	4,600 lbs.	1,900 lbs.
Defensive powers (deflective) Armour	12 in.	12 in.	12 in.
Defensive powers (deflective) Metal backing	12 „	12 „	12 „
Defensive powers (deflective) Inner skin	2 „	2 „	2 „
Ditto, equivalent to solid iron	24 „	24 „	24 „
Speed (average) in Knots	14½	14½	16½
Sail power	None.	Full.	Full.
Handiness to equal former Screw Line-of-battle ships.			Screw Frigates.
Propellers	Twin screws.	Lifting screw.	Lifting screw.
Length	360 feet.	360 feet.	377 feet.
Breadth	60 „	60 „	58 „
Draught	22 „	26 „	26 „
Tonnage	6204	6204	6123

In the line-of-battle-ships, the turret-guns would fire right ahead and right astern; in fact but very few obstructions to an all-round fire.

* The Russian Government already possess a 20-inch gun weighing 50 tons, throwing projectiles of 1,120 lbs., with a charge of 130 lbs. of powder.

In the coast defence, there would be no obstruction but the turrets themselves.

You will observe that the same offensive and defensive powers, the same speed, and the same degree of handiness are given to the Coast-defence as to the Line-of-battle ship, thus enabling them to be combined into one fleet for maximum uniform operations under steam; but inasmuch as in the Coast-defence vessel there are no masts and sails, and a less number of men and stores required, a less draught of water may be given, which for Coast-defence vessels is of great value, rendering them available for service in such seas as the Baltic.

To the ironclads for *Protection of commerce* I would give equal defensive powers of hull; the armament would consist of one gun, 1,000-pounder, mounted on a turntable on the upper deck, eight 150-pounders on the main deck at broadside, and probably, instead of a complete spar-deck, as in the Line-of-battle-ship, it would be better to have a full poop and forecastle, on both of which one 150-pounder chase gun would be mounted. The sails being worked in this ship from the upper deck, in the Line-of-battle ship from the spar-deck.

It may be said that such powerful projectiles and guns as 1,000-pounders, have not yet been produced in this country. True; but the probability, nay, almost certainty, is, that such will be manufactured within the next two or three years.

It may also be said that we do not yet know whether the hydraulic propeller may not, under all circumstances, be better than the screw as a propeller for ships of war. Then why not make fair and full experiments to prove the question?

It is well known that zinc is the best metal for preserving and keeping clean the bottoms of iron ships, but we do not know of the best method for fastening zinc to iron; why not make fair and full experiments to prove which is the best method?

Then, too, among others, there is the question of liquid fuel.

Considering that these vital yet unsolved questions, may revolutionize our whole marine, and entail another reconstruction of our Navy at a further cost of £12,000,000, is it wise to continue to build ironclad ships of the present fashion, involving an outlay of millions of money, before such important subjects as these have received full consideration, by judicious and exhaustive experiments? Yet, having regard to the national necessity, officially admitted, of augmenting the number of our ironclads, would it not be a wise economy to convert the best of our screw line-of-battle ships into practically as good ironclads as the "Devastation," involving but one-third the outlay in time and money. At the same time, a portion of the money thus saved might be judiciously expended, with advantage to the country, in making the experiments above referred to.

Thus should we obtain real economy with efficiency, and advance in the true path of progress.

The CHAIRMAN: Before the discussion commences, I should wish to state that General Skinner wishes to exhibit a propeller of his invention to-night, as he is, I believe, obliged to go abroad. I therefore hope that gentlemen who intend to

take part in the discussion, will adhere to the rule of the Institution, and confine their observations within the limit of ten minutes each.

Captain HEATHORN, h.p., R.A.: I should like to make one or two observations about gunnery matters in connection with these turret vessels. There are two or three things to be considered before we can lay down exactly what the guns of the future will be. One is the absolute manufacture of the present time: another the probable manufacture; and another, whether it is worth while making guns of such enormous calibre at all, seeing how difficult it will always be for men to handle their projectiles and fire them quickly. The value of heavy guns must always be weighed against the rapidity with which we can discharge them; and that consideration must always be thoroughly entered into before we can say that these very large guns will be accepted as a necessity in the future. At present we have had no experiments to show the value of "rapidity of fire" as against the "weight of projectiles."

The CHAIRMAN: I see two or three Officers present whose names have been mentioned, Captain Selwyn for one; perhaps he will offer some observations.

Captain SELWYN: Of course, I can never refuse to speak when called upon by the Chairman; and however reluctant I may be to be the first to speak before a meeting, most of whom probably know very much more of the subject than I do myself, yet as my name has been referred to, as holding very strong opinions on the subject of the utter fallacy of sending ships, as "men of war," to sea that cannot catch their enemies, perhaps I may be permitted to make one or two observations. That is one of the opinions I hold, and in which I thoroughly agree with Mr. Henwood. But then, I am not prepared to endorse many other of the opinions which he holds; and as one of those who generally think "the other side of the shield" worth looking at, especially worth looking at by those who are not interested in ship-building so much as Mr. Henwood is, I shall give free expression to my objections. Mr. Henwood started by lamenting the absence of classification; he finished by showing us the danger of entering into classification, and of constructing a larger number of ships before we had arrived at anything like an idea as to what was the best form of construction. I mean to say, in the present state of our ironclads, that we have secured after some years' fighting, the approbation of the English public, through the American press, for our own manufacture rather than for that manufacture which was pressed upon us, namely the "Monitor" type. It was the introduction of that type of ship which induced the gentleman who constructed the "Monitors" so to name them, under the idea that he was addressing a monition to the whole of the British nation. I think the Americans are not now quite so favourable to their "Monitors," but are rather disposed to agree with our "Monarchs." But it becomes us here as members of a scientific Institution, to recognize our own errors even where our cousins across the water do not perceive them. And there are an enormous number of errors being perpetrated at this moment in our ironclads. One of the very greatest of possible errors would be, if we were to put heavy iron armour, and heavy machinery exerting great power, on a wooden hull, which could not support the strain of the power we employ. Therefore, I dismiss at once all question of converting an old cart into a new coach. The next error we are committing is, I am sorry to say, advocated in very high quarters. It is that of substituting short ironclads, driven at great expense of fuel, for long ironclads, driven at small expense of fuel; and thinking that because such short ironclads cost less in building, therefore they cost less in maintenance. The ship which can only be driven for three days at fourteen knots by the expenditure of the fuel she is able to carry, is not as cheap, and never will be as cheap as the ship that can be driven nine days at the same speed with the same expenditure of fuel. It is vain to tell me, as has been done in this Institution, that we can go on a lower grade of expansion, that we can go a longer distance under that steam, provided we are content to go at lower speed; for as Mr. Henwood has observed, and as I hold very strongly, the speed of a fleet may mean the conquest of a continent. Neither will handiness under steam be more difficult to obtain with long ships than with short, wherever twin-screws or turbine-propellers are used. As for sailing long ships, if the masts are properly proportioned there is no seaman who does not know that the long vessel has an infinite superiority. But when people put up broomsticks and call them masts, it is

no wonder the ship will not sail. Next, we err entirely, if we imagine for an instant that the whole question is to be settled as between armour-plates and artillery, when we have settled what shot, of what size, will pierce what, armour. For a very slight improvement, an improvement which is going on to-day, the beginning of the study of which was shown at the Royal Society on Saturday night, will tell us that a slight change in the nature of our cartridge, and in the development of the gases arising from the powder composing that cartridge, will give an added velocity to the same shot out of the same gun, which will set at naught all our previous calculations. This gentleman shows us that the defensive and offensive powers ought to be equal; but we cannot rely upon anything like the offensive and defensive powers being equal. It is a very pretty maxim, a magnificent thing in theory. But if you will tell me whom I am to meet on the ocean, I shall then know whether I am to be pierced by a shell, or by a shot, arriving from a little wretched "Staunch" gunboat, which may not have any armour at all, and whose defensive and offensive powers are certainly not equal to a ship which has such an equality. Thus, it is a question of an ironclad of 6,000 tons being pierced by the said gunboat having offensive and defensive powers of retreat to where she cannot be followed. You see the whole thing becomes a mere folly when it is reduced to practice. You cannot rely upon any such thing. In respect of the question of turrets, I am sorry to say that I am totally at disagreement with both my friend Captain Cowper Coles and Mr. Henwood. A turret vessel which is principally valuable for coast defence, certainly should not draw as much water as the "Great Eastern," and it is a great failure when she does so. A turret vessel which is to be principally available at sea, should certainly not be obliged to submit to the water washing over her. A turret vessel which is also to be valuable at sea should certainly not have such a contrivance to avoid difficulties as tripod masts, for it is merely a contrivance to avoid difficulties. Rigging being inadmissible, tripods were introduced, which are excellent things as long as the centre of gravity falls within the base, but which utterly fail to be any support to the weight above the instant the ship inclines and the centre of gravity no longer falls within the base. There is a second objection to that plan which is very fatal indeed; which is, that in the smoke of action, with such guns as you propose to use in turrets, it would be perfectly impossible to prevent your own shot cutting away your own masts. The ordinary masts are, in most of our modern ironclads, ill adapted for the purpose of sailing power. They number some three, four, or five; but the introduction of tripods multiplies them to nine in the case where there would be three, and to fifteen where there would be five. So you have positively introduced a number of vulnerable points, which are not, it is true, essential to the motive power of the ship because she is moved by steam, but which are most objectionable when you come to tumble wreck on to your turret, and to find that they cannot be moved, that you cannot see your enemy, and cannot do anything. What has been introduced? A light spar deck; another composition with unavoidable evil, beset with difficulties, because the spar deck is essentially liable to be destroyed by shot, and so to choke your turrets again. What, again, has been done to prove the question of the magnificent all-round fire of the turrets? We were told that a turret would fire ahead, would fire here, there, and everywhere; but when we look at the models which are brought before us, and we remember the construction of the "Captain," we find that a forecastle and poop are found to be a necessity; consequently, the all-round fire no longer exists. We find that nothing has been done to obviate the difficulty of heeling, and, consequently, the interposition of the deck between the ship's guns and her enemy; that nothing has been done to compensate for the calculation that you must carry 300 tons of turret in order to carry 44 tons of gun. Does any one mean to tell me that these 300 tons of armour in the turret could not be more profitably employed in guns or armour on the broadside of the vessel? Does any one mean to tell me that it is necessary to employ one special armour for the gun, and another for the ship? Does any one mean to tell me that six feet below the water line is any protection to a ship at sea—that she cannot be pierced through and through by every gun that is fired at her when she is lifting over the waves? All these are things which we ought to consider before we advocate strongly any one form of vessel. We are in a state of transition in our Navy,

and he alone will act wisely, who gives a great deal of time to experiment, who gives a great deal of money to experiment, who does not cut down an experimental vote for the Navy from £12,000 to £2,000,—incurring, hereafter, an expense of £100,000, perhaps half-a-million in one experiment on a large ironclad that does not answer. These are the things which, if an Institution of this kind is to be of any use to the Government, ought to be forced upon their attention. They ought to be told that they are not doing wisely in adopting anybody's theory; that it requires slow and careful experiment, not in harbour but at sea. Do not let us have the fallacy of the measured mile and the six hours' trial. On that point I entirely agree with Mr. Henwood. We have trustworthy Officers, I hope at sea, who conduct these ships. Let us have their reports of the speed under all conditions at sea; whether the ship's bottom be foul, which cannot always be avoided, or whether it be not so; but let us have their reports, and no pet stokers put on board, no pet coals, no pet boilers, no pet funnels, no pet anything. Let us get the truth, not a parcel of fallacies, such as we are getting every day now. If we want to know how to conduct ships at sea, I do not think any person, however highly placed, will acquire that knowledge in less than the usual time which, in every technical profession, is devoted to acquiring a knowledge of that profession; and I think he will be very unwise to take up the ideas of one set of persons he comes in contact with, put them down as rules, and proceed to act upon them, upon a large scale. I hope, therefore, that we shall have free and full discussion, honest and careful, as well as ample experiment, and thus we shall make a progress in which no excuses will be necessary for shortcomings, for all that it was possible to foresee, will have been the subject of forethought; few mistakes will have to be regretted, for they will have been corrected as they arose, and before they were stereotyped.

Mr. C. Lamport, N.A.: To save time, I will venture to obtrude myself now upon the meeting to express my satisfaction at what has fallen from Mr. Henwood in regard to the inefficiency of our existing Navy. I trust that what he has said so clearly and so well will do something towards opening the eyes of the people of this country to the fact that our Navy, as it now exists, is a sham and a delusion. The Right Honorable the First Lord of the Admiralty, in introducing the Estimates the other night, stated that the number of our ironclads was 47. The fact is, that 27 of that 47 consist of the old 4½ inch ironclad ships, or what is equal thereto; and such plates are no protection against our modern artillery. And I do say, that if any Board of Admiralty were to send such ships to sea, with the chance of meeting even such vessels as the French could bring to oppose to them, or such as the Americans, undoubtedly, have afloat, they would be as culpable as if they sent our old screw wooden steamers to meet such vessels as the "Warrior" and the "Achilles," when they were the best ships afloat. Of the other 20 ironclads of which our Navy consists, as far as I can make out, 12 are still on the stocks, leaving some 8 afloat; and of these 8, according to Mr. Reed's own statement, the "Hercules" is the only one that has a chance of resisting the artillery of the present day at short ranges. But I may further add (and we have a competent authority here this evening, who tells us this plainly in so many words), that the "Hercules" herself is not capable of resisting large guns any more than the other vessels. Now, if we use this redoubtable paper fleet, shall we not be doing very much what the Chinese are accustomed to do, to deceive their enemies when they go to war? Gentlemen know pretty well that their plan is to erect painted fortifications, which at all events have the chance of deluding their enemies; whereas, as to our boasted paper and pasteboard defences in the "Warrior," and ships of that class, the only success is in deceiving ourselves. I am certain there is no French or American authority who does not know that if we were to send our 4½ inch ironclads to sea against their best ships, we should be sending them to certain destruction. There is an old Greek proverb, Εἰς μαγειρος ου φοβει πυλλα προβατα, "one butcher does not fear many sheep." If one of the American turret ships, or one of the French rams, which carries larger guns than any of our existing ships, were to meet a flock of our "Warrior" sheep, I ask what would be the result? There would be a Triton among the minnows; a sword-fish in a shoal of whales; it would be the "one butcher" going out to work his own will, at his own pleasure, in his own time,

among a flock of helpless sheep. Now, is this a fair and proper position for this country, which boasts a maritime superiority, and which claims to be the mistress of the seas? is this a fair condition for us to be in, that we have not more than one ship to send to sea fairly able to cope with the guns of the present day? So far I am willing to go with Mr. Henwood. But in regard to the future, I must say that I part company with him, sharply and entirely. If he disregards the lessons which the last ten years have taught us in the monstrous failure that exists now in our armour-clad Navy, he is not the man that I believe him to be. Why, he has already told us of the difficulties that stare us in the face. He tells us we do not know what is the best ship. There I agree with him: we do not know. And Captain Selwyn with all his ability, when he condemns turrets, cannot tell us. He may blame the turret, and another may blame the broadside: what of that? Mr. Henwood spoke of a 1,000-pounder gun. The thing is a myth; it may or may not be. Mr. Reed says that he has already put before the Admiralty designs for a ship with 18 inches of armour on the broadside, and to carry 20 inches thick upon her turrets. Why, good gracious! if this kind of thing is to go on, where are we to stop? My idea is, that we shall pull up in this way; we shall find that ships and guns are running a fool's race, and we shall turn round and try something altogether different. We shall do as they did in the fourteenth and fifteenth centuries, after the invention of gunpowder and bullets. The "warriors" of that day first tried to strengthen their defensive armour. Then they saw their error, and left it off altogether. And really I think we are already entering on that wise course; for, passing from armour-clads, I do not think we have a more efficient ship afloat than the "Inconstant," a vessel unequalled in speed, and capable of carrying, if necessary, a gun of the largest calibre. She can escape if she is overmatched; she can overhaul if she chooses to enter into conflict, and what more do we want? Surely, that is the kind of ship we need to protect our commerce. As regards our home defences, Mr. Henwood would ask us to build a lot of these ships (pointing to the diagrams). Why, has the question of torpedoes been thoroughly gone into? has the matter of gun-cotton been thoroughly tested? do we know whether double screws are right? are we satisfied that turret ships are correct? or whether such a vessel as the "Staunch" is not, after all, the true type of the future ship? I think these questions ought to be answered before a man of even Mr. Henwood's practical ability should venture to lay before the members of this Institution designs of the fleet of the future. I think Mr. Henwood has been playing to-night the part of Macbeth, with new scenery, new dresses, and new effects. He has been trying to give us the typical ship of the future. As Macbeth did with the air-drawn dagger, he says, "Come, let me clutch thee." Failing, he exclaims, "I have thee not." And then, with true British pluck and persistency he adds, "And yet I see thee still!" Now, I do think we ought to consider that the history of the last ten years has been conclusive to show that the present, like the past, is so thoroughly a period of transition, a time of invention, that any attempt to expend the money of the people of this country upon a Navy which will carry out traditional policy of this country, and overmatch the Navy of every other country, is a delusion and a snare. I for one trust and hope that we shall be disposed to hark back in this matter; that we shall awaken to the fact that the true preparation for war is not in sham ironclads, and in running a fool's race between guns and plates, but in keeping in our pocket the true sinews of war, which is money. I ask any gentleman present, considering what Mr. Reed told the people of Sheffield the other day, that £110,000,000 have been spent during the last ten years, and all that we had to show for it was our armour-clad fleet; and if that is valueless, as Mr. Henwood says it is, I put it to you, gentlemen, whether we should not be stronger and better prepared with the £110,000,000 in our pockets, ready to lay out at once, even with all the evils of haste, upon the best ship, or gun, or engine of the day, when we go to war, than if we now rush forward, and expend it on what to-morrow may supersede, and have, too late, to gather wisdom, with the loss of men and money, from the failures that we shall have made?

Rear-Admiral INGLEFIELD, C.B.: I cannot pretend to address the meeting at all like the eloquent gentleman who has just sat down. But as a naval Officer I must say there is a point which we ought not to lose sight of. The gentleman tells us

"our fleet is a sham and a delusion!" I must really protest against such an expression. Having lately been cruising with the Mediterranean and Channel squadrons, and having seen the French squadron at sea, I know something of the actual state of our navy. It must be borne in mind that though our navy is in a state of transition, it is not only keeping pace with, but is always in advance of the navies of other nations. That is a consideration we must keep in view, before all others, with reference to our fleets and our armaments. As long as we can claim to be in as good a position as any other maritime nation, if not a better, I think that is as much as we can expect, considering the progress that is going on on all sides. To have the sinews of war in our pockets will be a poor protection when the hour of battle arrives. To say that we are so rich as to be able to produce in any given space of time, squadrons ready to go upon the seas, will afford but a poor chance for us when our shores are threatened by the squadrons of other countries. Therefore, I must again protest against *that* part of the gentleman's speech in which he talks of our navy being only a sham, and recommends us, as the best substitute, to keep our money in our pockets until we knew how best to spend it.

The CHAIRMAN: Now, Mr. Henwood, will you reply?

Mr. HENWOOD: I think there are very few criticisms for me to reply to, with the exception of those by Captain Selwyn, who seemed to imagine, as I understood him, that I proposed to build new wooden ships and to armour-plate them.

Captain SELWYN: No, no, to make a new coach out of the old cart.

Mr. HENWOOD: Well, that is not my proposal, but simply to utilize the sound and strong ships which have engines already in them. I merely take away the useless wood and add the same weight in iron, as has been done in the case of the "Ocean." The "Ocean," be it remembered, has performed a voyage out to China most satisfactorily. We cannot make any mistake about the matter of weights, because a ton of iron will not weigh more than a ton of wood.

Captain SELWYN: May I ask—I ask only for information—how long does an iron ship last, and how long does a wooden ship last when under the screw?

Mr. HENWOOD: That depends on the power of the engines. You cannot drive those line-of-battle ships beyond 12½ knots, but you drive the "Hercules" 14½ knots. These wooden line-of-battle ships have not the powerful engines you imagine; they have moderately powerful engines. And as to the putting on of weight straining the structure, that is an entire fallacy; they would be, if converted, as strong practically, for all war purposes as an iron ship, and last 25 or 30 years. Mr. Lamport, I think, in reference to the proposed "future ironclads" imagined that I proposed to build such ships. That was not exactly what I did propose. I merely brought them forward as an indication of the probable future. I stated in my paper that I thought we should not build new ships at present, but that we should utilize what we have; and in the meanwhile, make experiments towards future progress. With regard to Captain Selwyn's objection to the turret, I might leave that to Captain Coles, for I think before long he will give us a paper on the subject. But the objection that Captain Selwyn made was that you employ 300 tons of armour to protect two guns in a turret. Now, whether the guns are in a turret or in a "box," you would have about the same weight of armour; and it is much better to distribute four guns in two turrets, than to concentrate four guns in one "box." Then there was another point. It was said that we are keeping pace with other nations in regard to our navy. That may be so, but formerly it was considered necessary that we should be a long way ahead of other nations. Now, we are merely on a par with them, and the question is whether that is a satisfactory position. The present First Lord of the Admiralty at all events does not think it a satisfactory one, because he tells us we must go on building year after year a very large number of ironclad ships as well as wooden ships.

The CHAIRMAN: I have now to propose a vote of thanks to Mr. Henwood for the very elaborate paper he has brought before us. In doing so, I do not express any opinion upon his views, which embrace a large number of subjects, and upon which we all have our different opinions. Nevertheless, we are very grateful to him for having brought this question before us, and for having given the opportunity for a discussion. Whenever there is a discussion on matters of this kind, carried on as our

discussion has been to-night, it must be attended with advantage. Different views are put forward, and being discussed in a friendly spirit, the result must be advantageous to the Naval service as well as to the country. It is with this special object that the Council invite gentlemen to lecture in the theatre of this Institution. I have now to ask General Skinner to explain the principle of his propeller.

ON A CYLINDRICAL PROPELLER, WORKING ON A VERTICAL SHAFT IN THE MID-SHIP SECTION OF A SHIP.

By Major-General P. K. M. Skinner, C.B.

Mr. Chairman, Ladies and Gentlemen,

I would invite your attention for a few moments, while I do myself the honour of offering some remarks on Steam-ship Propellers, and of submitting to your criticism models, which incorporate an idea that is destined, I believe, to effect a great improvement in the propulsion of steam-vessels.

I present to your notice a new description of propeller—I say new, because it is my own invention. I have searched diligently to discover whether I have been treading in the footsteps of others, or infringing rights to which I have no manner of claim, and I am happy to declare that I can discover no description of propeller similar in form or action to the one I have the pleasure of making known to you this evening.

All propellers hitherto designed, depend on the horizontal principle of action, excepting, perhaps, Ruthven's hydraulic propeller, of which I have no information; all are fixed on a horizontal main shaft. This, although the plan that first suggests itself, involves, in practice, many difficulties and much loss of power.

With the ordinary paddle-wheel, there is loss of power, and a tremor caused through the ship as each float strikes the water; the corresponding loss of power as each float resumes the horizontal position on emerging; the impossibility of keeping the vessel in such good trim, that both paddle-wheels shall take sufficient water, and no more, too deep an immersion wasting the engine power, and too little merely throwing up the water without driving the ship—these are matters that I need not enlarge on; they are difficulties inherent in the construction of paddle-wheels, and which have been only partially overcome by feathering paddles and similar expedients.

We may state, then, that for all sea-going vessels, where economy of fuel must be considered, and the combination of sail and steam maintained, the screw-propeller has superseded the paddle-wheel. The screw propeller does not, however, convey to our minds the idea of a perfect machine. It is placed at the end of a long shaft, resting on bearings, which, to ensure the correct working of shaft and screw, must always remain true; and it is known that on several occasions the screw, or boss with its fans, has been broken off and fallen into the sea, leaving the ship unable to pursue her course, as far as steam power is concerned. The shaft passes through a water-tight (or sup-

posed water-tight) stuffing-box, and may, in case of strain or fracture, so injure or enlarge the aperture in which it works as to endanger the safety of the ship; or it may possibly be removed from its place by fracture, and thus leave a large opening for the sea to rush in; and, in the twin screw-ship this danger is doubled. It is not improbable that several of the screw-propelled ships that have gone on distant voyages, and have not since been heard of, have been lost in this way.

When a screw-propelled ship pitches in a heavy sea, it not unfrequently happens that the screw is lifted clear of the water, so that the fans spin round with great rapidity, and then comes a terrific check to the engine as the screw plunges deep into the sea, and receives a shock tending to injure the machinery and strain the shaft. Again, the action of the screw in the same water as that acted on by the rudder, makes steering sluggish: nor is the reverse action of screw propellers satisfactory.

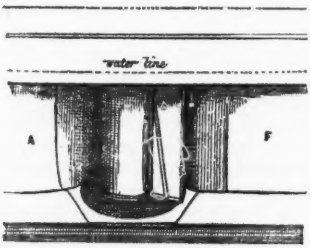
In a ship rolling heavily, the paddle-wheel proves a very defective propeller. At one time lifted entirely out of water, and at another almost submerged, the wonder is, how the vessel advances. In my propeller, under all circumstances the blades are constantly immersed, either partially or entirely, so that all liability of the racing of the engine, as it is technically termed, is in consequence avoided; and when the blades are totally submerged, the action of the propeller is increased; nor is any leakage to be apprehended from this cause, for no water can find its way into the hull of the ship by the aperture through which the main shaft works, no matter how large it may become, for it is placed high above the water line.

I claim, then, for my propeller the advantage which the paddle has over the screw, in being placed in the best part of the ship, where both the vessel is strongest, and where the propeller imparts motion to the ship at the best advantage; where, in fact, by propelling on one side, and reversing on the other, the ship will be turned in her own length. In reversing, the action of my propeller is just as immediate as that of the paddle, and far better than that of the screw.

I claim over the ordinary paddle the advantage of not losing the power it does in the immersion and emersion of its floats. I retain the advantage which the screw has over the paddle in fixing its blades under sail, with the additional advantage that the blades of my propeller can be fixed fore and aft on a line parallel with that of the keel —a position that offers no resistance whatever to the impulse obtained from the sails, and, finally, I lay claim for my propellers to an immense advantage over both screw and paddle, namely, that if one is disabled or injured, it can be hoisted on deck, repaired and replaced at sea, the ship continuing her course in the meantime with the other, by the aid of the rudder.

The propeller which I shall now describe consists of a drum or cylinder, placed on each side of the ship in a vertical position, with a wheel on the head of a shaft, driven by a wheel, attached to the main shaft, which may either be horizontal or vertical, according to the description of engine and driving gear employed. (In my models and diagram the main shaft is horizontal.) And here I shall remark that it is

not necessary that the main shaft should be placed directly athwart the vessel, as required in a paddle ship, nor directly fore and aft, as required with a screw, but in whatever direction it may be convenient to



place them to suit the engine. The working models before you have their main shafts oblique to the keel of the vessel.

In the drum and passing transversely through its centre and throughout its whole depth, is a traversing blade or fan, the ends of which are so guided by an oval rib or guide, that in every revolution of the drum each end is alternately pushed out and brought back in such a manner that it is pushed furthest into the water at the point of the revolution where it acts most favourably for driving the ship forward.

To overcome the friction of the lower edge of the blade, due to its weight, I sling it from the top, so that horizontal motion is perfectly free, and to remove any side friction there may be against the sides of the slot I place friction rollers at top and bottom.

This model is on a scale of half-an-inch to a foot, so that, in reality, this drum represents a drum 10 feet high, and 6 feet in diameter, and the width of the fan or blade 4 feet, which would give an area of 10 feet by 4 for the blade, when acting at its best.

With regard to speed, as each revolution of the drum is equivalent to a forward motion of 24 feet, and as there would be no difficulty in giving the drum a velocity of 60 revolutions to a minute, a speed of 15 miles an hour may be counted on, for I do not see how any appreciable slip will arise.

As this model has been tried in the water on several occasions, and, though moving rapidly, the water has been but slightly agitated by the propellers, I might suggest the adoption of this description of propeller for ships navigating the Suez Canal, where water much agitated has a tendency to destroy the banks.

I would only say in conclusion, that each point connected with this invention has been the consideration of many years, indeed, far more carefully considered than this meagre description would lead you to suppose, and many trials have been made of working models during that time, and up to the period of the completion of these now presented to your notice. These models give every promise of the sufficiency of the design, and have suggested no difficulty.

Admiral INGLEFIELD: How far below the water would the top of the aperture for the propeller be?

General SKINNER: It would be 2 feet below water. But if I were to build a vessel, I would make it still lower, and would make the propeller smaller. It does not require so large a propeller as that, and then the propeller would be much more under water. The ship would draw 18 feet of water.

Admiral INGLEFIELD: I asked the question, because a man-of-war in rolling always exposes the paddle. What would be the effect of shot striking your propeller?

General SKINNER: I would place the propellers much lower. I think the propellers are too long. You would have one advantage by having them not so long that you might have them continually under water. But this is not intended for a man-of-war alone: it is intended for merchant ships.

Captain HEATHORN, h.p. R.A.: Could you not multiply the propelling power of that blade or fan by which you propel the ship, by increasing the number of drums, if necessary? If you wished to reduce the drums in depth, could you not get the same power by increasing their number?

General SKINNER: You might do that, but I think it would take up too much of the vessel to put a drum here and a drum there.

Captain HEATHORN: But it might be done in order to do away with the difficulty of bringing the top out of the water, and so exposing the propeller to shot.

Mr. STERLING LACON: Can you give us the result of any experiments on a larger scale than those made with the models on the table; because there is a vast difference between theory and practice?

General SKINNER: No, I am unable at present. I am now building a boat 12 feet long. I can only say I have had the model of a twin-screw propeller that I built 13 years ago, and it did not go faster than this, although it went very rapidly indeed. The model is now in the South Kensington Museum, I sent it to the Admiralty, and the Admiralty kept it about two years, and then said it was useless.

Mr. MACKIE, C.E., asked if the inventor had estimated the amount of floatation power lost in the vessel by taking the slice out of her midship area for the access of water to the propellers?

General SKINNER: There has been no calculation made of that nature. But then you give a ship of this kind great breadth of beam. The length is a little more than four times the breadth. This model would represent a ship of 176 feet long by 42 broad; and this form of the vessel would be an impediment to her rolling.

Admiral INGLEFIELD: Is it imperative that the apertures should be exposed? Could not the propeller be protected by armour plating outside?

General SKINNER: I have had one that was protected, but it was too much enclosed. The fans would not have free access to the water if they were enclosed.

Admiral INGLEFIELD: But if there was a channel through which the water could pass.

General SKINNER: I scarcely think it would answer.

Admiral INGLEFIELD: It is suggested that by armour-plating the propeller might be protected.

Captain SELWYN, R.N.: There are several engineers present; there are also a good many naval architects; and I have waited in the hope of hearing some refutation from my brother officers of what, I for one must say to General Skinner, requires very deep consideration. I am afraid it should go out from this meeting of our Institute, that we encourage an inventor to come forward and to propound to us what the shipbuilders, engineers, and naval Officers who are conversant with steam, must know is a proposition to retrograde, exactly in defiance of all our laws of mechanics, of everything that we have done yet, and go back to a bad implement, badly placed, worse-placed than ever it was before—and to sacrifice for the sake of doing so a large proportion of the tonnage of the ship, to sacrifice for the sake of doing so all possibility, at high speeds, of the water ever getting to the motor at all. We cannot for an instant suppose that this is a thing which has not been considered before, because all of us here know very well that such ideas have been before the world many times. I am most reluctant to be obliged to say what I have, but I should also be very sorry that the sanction of this Institution should in any way be given to what I am afraid we must pronounce a great fallacy.

Captain HEATHORN: May I be so bold, as a soldier against a sailor, to ask on what grounds Captain Selwyn pronounces that this is so heavy a failure. We are ignorant, and would like to know. There is no doubt of this, that it has an advantage over the old paddle-wheel, in this respect, that after it has given the blow it has not to strike the water down. Again, as regards other propellers being fixed in the sponsons of ships in this way, the first screw propeller that ever came out, which answered very well in model, (for it has never come to the front,) was a vessel with screw-propellers put in the sponsons, very much where paddle-wheels are now placed. They worked independently, and vertically on each side, and they answered exceedingly well in the model. Therefore, vertical machinery to work a vessel has not altogether failed. This is a paddle-wheel (as far as I can see) which does not possess some of the demerits of the ordinary paddle-wheel. And the fact of your being able to repair it and refit it under certain circumstances appears to me very practicable. But before a gentleman of such great experience as Captain Selwyn completely runs it down before this audience—for I am sure there are many soldiers in the Army who do not know anything about ships—I think he ought to explain to us a little more what its demerits are.

Captain SELWYN: If the Chairman and the meeting are of opinion that I should proceed to explain the reasons why the thing cannot operate properly, I shall be most happy to do so.

The CHAIRMAN: I am afraid that if we begin to discuss the merits and demerits of every statement that Captain Selwyn has made, we shall be a long time in coming to a conclusion. If the Board of Admiralty took two years to decide upon the merits of General Skinner's other invention, I am afraid that at this late hour of the night we shall scarcely be able to come to a satisfactory decision. Questions of this kind, when carefully examined, raise very intricate points, both theoretical and practical; and I think, in justice to General Skinner himself, it would be almost impossible to discuss the question so thoroughly as to decide whether his is a practicable invention. These inventions can only be tested on a large scale; to test them by models is only likely to mislead. Therefore, unless the meeting earnestly desire it, I propose now to conclude with a vote of thanks to General Skinner, and to express a hope that when his larger vessel has been thoroughly tried, he will be good enough to give us the result of those trials.

Admiral Sir EDWARD BELCHER: I wish to make one or two remarks. This is a very pretty model, and a very pretty idea. But as far back as the year 1818 I tried something in a similar way between two keels, with the paddles passing over the bows between two stems and keels coming up above, horizontal between two rudders, to destroy the undulation, it being intended for use in towing barges on the Runcorn Canal. However, the question before us now is, whether this invention is fitted for Her Majesty's Service. Having taken very great interest in the turbine, I can only say that the turbine, of which this seems to be a variation, has been proved. The Admiralty has constructed a vessel on that system, and the turbine, although primarily supposed to give 8½ knots, actually on trial gave 10. The trial between Mr. Reed's "Viper" and "Vixen," and the "Waterwitch," resulted, to tell the truth, in a victory for the "Waterwitch." Now, as the turbine works out of water, or under water, or indeed under any difficulties, and gives all the velocity that we require; as it is perfectly protected from shot, and as it possesses one other extraordinary advantage, which is, that it will overcome the flow of water from any sized shot hole, however large, that is, provided it is not so large as the opening behind you (four feet square), and considering that the turbine of the "Waterwitch" will throw 1,000 tons of water per minute, the turbine would take the wind out of the sails of this very pretty thing. I admire the thing very much, and I like the idea. But we should lose an immense amount of tonnage by that slice cut out of the ship fore and aft; further, every time the ship rolled, the enemy would take quiet aim and destroy the exposed machinery, therefore, I do not see that the invention is applicable to the Royal Navy. As to a boat on a canal, or a yacht, or a merchant vessel, I have no doubt it would prove useful.

The CHAIRMAN: I will intrude by again thanking General Skinner for the trouble he has taken in bringing this invention forward.

Evening Meeting.

Monday, March 14th, 1870.

REAR-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 7th and 14th March, 1870.

ANNUAL.

King-Harman, M. J., Lieut., R.A. 1*l.*
Baker, James, Lieut.-Col., late Cambridge University Volrs. 1*l.*
Hart, John, Lieut. 100th Regt. 1*l.*
Martin, G. W. T., Lieut. 46th Regt. 1*l.*
Maxwell, H. H., Colonel R.A. 1*l.*

THE FIELD GUN FOR INDIA.

By Colonel H. H. MAXWELL, R.A.

1. UP to the year 1862, the armament of the Indian Field Artillery consisted of 9- and 6-pounder guns, and 24- and 12-pounder howitzers. The field-battery pieces were lighter than those in use in England, weighing only 10 cwt. The horse artillery pieces were identical with those of the home Service.

About that date the first breech-loading Armstrong battery reached India. I can tell you little from my own personal knowledge of the efficiency of the guns in that country, as the superintendence of the Indian Gun Foundry fell to my charge at the same period. Gradually I came in contact with them in another way. All sorts of strange things came into my hands, sent to me as patterns for manufacture, of whose use I had only read. But at last, a 6-pounder breech-loader Armstrong gun, split in the powder-chamber, came to me for repair, if possible. With a feeling of despair I was compelled to return it, with an intimation that its repair was beyond my power.

Chance threw in my way, in 1865, a description of the French field gun, and at the same time I learnt that it had been tried at Shoeburyness, and that its practice was found equal to that of the 9-pounder breech-loader of the Service.

I heard, too, that the Dutch in Java had adopted the French system, and manufactured the guns and their equipments on the spot.

I came to the conclusion that a gun of this description was precisely what we wanted in India, as we had an ample stock of bronze in the country. I appealed to the powers that be; my proposals were favourably received, and were sent to England for submission to the Ordnance Select Committee, who reported not unfavourably of them.

Just at this time the Armstrong and Whitworth controversy had been fought out on the sands of Shoeburyness. Muzzle-loaders began to hold up their heads, the Navy especially objecting to breech-loaders. The next step in the history was the assembly of a Committee of superior Officers of Artillery; they reported unanimously in favour of muzzle-loading field guns.

Then followed experiments with steel-barrelled iron-coiled guns and a bronze gun of the same size and shape. The experiments were so far unsuccessful that these guns were beaten by the Service breech-loaders in accuracy. The poor bronze gun soon gave in, after having been treated to a few shells with cast-iron ribs, which struck out a line of rifling for themselves.

Finally, in December, 1868, a Special Committee was appointed under the presidency of General Eardley-Wilmot, on the Equipment of Field Artillery for India.

I feel sure, in mentioning General Wilmot's name as President, that the recommendations of the Committee will derive additional weight in the minds of those now present. After a long series of experiments, that Committee proposed the adoption of a muzzle-loading 9-pounder bronze gun of 8 cwt. as the sole gun for the Horse Artillery and ordinary field batteries in India. The gun has been so far adopted into the service, that the 9th Brigade of Field Artillery is about to be armed with it. To give you some idea of the piece and of its powers, is my object in addressing you this evening.

2. Until within the past year there existed, and perhaps exists still in the minds of many artillerymen, a somewhat ill-defined impression that a breech-loader *must* shoot better than a muzzle-loader. I, for one, hold that this is by no means the case. The muzzle-loading small-arm rifle is in nowise inferior to the breech-loader in accuracy. Why should the reverse be the case with guns?

I may be told that in the breech-loader the non-existence of windage is sufficient to demonstrate that it must shoot better than a gun with windage. I demur. I say, if I can centre a muzzle-loading projectile and keep it centred as it passes along the bore, I shall have at least as fair a chance of making a good shot as the breech-loader, which at best can only do the same.

But to quit theory and to come to facts. What is the result of actual practice? Why, simply that as regards accuracy and uniformity of range, there is little difference between the two systems.

If *greater* accuracy, then, is no longer allowed to be the peculiarity of breech-loaders for field guns, that system, according to my lights, has not a leg to stand on. For we know, as regards rapidity of firing, that there is no advantage one way or the other.

I do not think I have ever seen the matter better put than in the Professional Tour Report of the Royal Artillery Officers who visited Russia in 1862; it was in these words:—

"The Russians are generally opposed to breech-loading for all ser-
"vices, as being unnecessary in the field, and impossible for large
"charges and heavy guns."

That is, just where they would be useful they fail; and where they

Fig. 3.

a . *Driving side*
b . *Loading side*

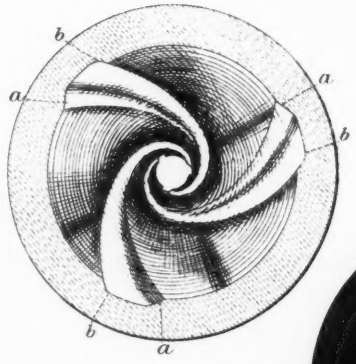


Fig. 2.

Fig. 1.

Fig. 4

J. Jobbins

would be of no especial service, they may be used by those who like complication.

I have been told that the Russians have gone back from this wholesome doctrine, and have taken to the complications they formerly believed to be unnecessary. I confess, in one sense, I am sorry for the Russians, as I firmly believe they have some bitter experience to buy in the matter. They have been frightened by a bugbear. They held that bronze was too soft to stand the wear of rifled projectiles, and that if the metal of the studs were softer than that of the gun—perhaps the only condition upon which the guns could stand the wear—the studs would be knocked to pieces in travelling.

3. The French at the outset of their experiments got deplorable results from their bronze muzzle-loading guns. As the shell lay at the lower surface of the bottom of the bore, the cast-iron was in contact with the gun-metal; the stud was used merely to compel the shell to follow the twist of the groove, and not to protect the bronze of the bore from the cast-iron. What was the consequence? The windage or space between shell and gun being at the upper surface of the shell, on the explosion of the charge the upper edge of the base of the shell struck the top of the bore, while the shoulder of the shell was hammered down on to the lower surface. This sectional diagram will perhaps illustrate the effect. You see that the shell did its best to revolve round its shortest axis, and you may imagine how a shell thus started, behaved itself as it passed along the bore. It was about on a par with the old round shot, and some fifty rounds rendered the gun unserviceable.

Enlightened by this misconduct, they made the studs project farther beyond the surface of the shell, so that when it lay as before, at the lower surface of the bottom of the bore, there was a clearance between cast-iron and bronze.* The gun was thus subject to the friction between the zinc of the stud and the bronze of the driving sides of the grooves. Under these conditions the guns shot well and endured long.

The Austrians having suffered under these guns in 1859 in Italy, studied the matter, and in 1863 introduced a centring system applied to muzzle-loading guns. The diagram† will give you an idea of that system. The projectiles are formed of a similar figure to, but of a slightly smaller diameter than the bore of the gun, and are covered with a coating of an alloy of tin and zinc. This alloy being softer than bronze, the friction between the two metals is favourable to the latter in point of wear; but owing I suppose to the sharp angles of the surface of the alloy, each projectile has to be carried well greased in a canvas bag in the ammunition boxes. This appears to me to be the defect of the arrangement.

The French guns fire between two and three thousand rounds with satisfactory practice to the last. The Austrian guns fire some 1,500 rounds, after which service they are recast.

* Vide Fig. 1.

† Vide Fig. 4, representing a vertical cross section through the gun and shell, the latter lying at the lower surface of the bore. When centred, the windage forms six lozenge-shaped figures when seen in section.

Fig. 3.

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b . *Loading side*

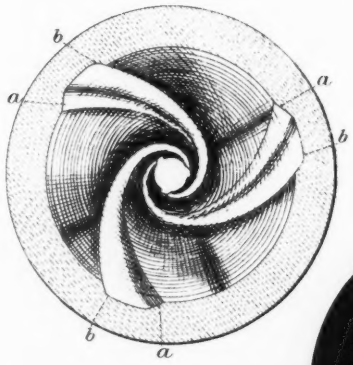
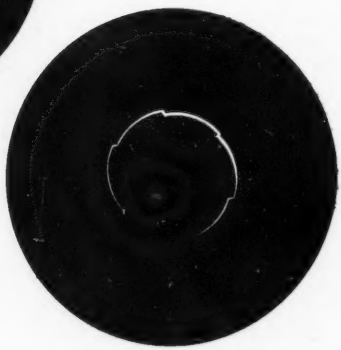


Fig. 2.

Fig. 1.

Fig. 4



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I have thus shown you, I hope, how a projectile, composed of the hard metal, cast-iron, can by a little artifice, be fired from a gun made of a comparatively soft metal like bronze. It is, in short, by isolating the cast-iron from the bronze.

4. But the metal of the gun has more to stand than the mere friction of the studs of the projectile: it has *first* to sustain the expansive force, and *second*, the great heat of the powder gas.

Now as to the first point—the expansive force—I believe there is no known metal or combination of metals which gives such absolute security from bursting as bronze. It is, not that an individual steel gun with or without wrought-iron coils, may not be stronger perhaps than an individual bronze gun of the same size; but take 1,000 bronze guns, and you may be perfectly certain that not one will burst. It remains to be seen if the same is the case with steel guns, with or without wrought-iron coils.

The Prussian Ordnance Committee made some interesting experiments on the resistance of bronze. The guns used were the 4-pounder and 6-pounder. The former fires a shell of about 9 lbs. weight, while the gun weighs about 6 cwt., and the latter a shell of about 15 lbs., with a weight of gun of 9 cwt.

I will confine myself to the former. They turned down the gun of 6 cwt., a small quantity at a time, until it weighed only 2 cwt., the thickness at the breech being reduced from 2·4″ to 0·8″, and at the muzzle from 1″ to ¼″. With this gun they made a series of experiments, firing a 9 lb. shell with a charge a little over 1 lb. After each series, the bore was examined to find out where expansion first took place. It was only after the thickness at the seat of the charge had been reduced below 1½ inches, that expansion took place. Further, with this thickness, expansion took place after a few rounds and then ceased. When the gun was reduced to a thickness of under a ¼ of an inch, small cracks were observed through which the powder gas escaped; the gun was, however, fired with safety.

The heavier gun of 9 cwt. with a shell of 15 lbs. and a charge of 2¼ lbs. when reduced to $\frac{3}{10}$ths inch thickness at the muzzle, burst, throwing a good large piece out of the chase with violence. Thus there was ample indication of approaching rupture.

Incidentally I may mention that as the guns were reduced in weight, the charge of powder and weight of shell remaining the same, the guns were most destructive to their carriages; a circumstance which we all could have anticipated, but one involving a true principle of construction not sufficiently borne in mind, viz., heavy gun and light carriage. I shall have occasion to allude to this further by and by.

The resistance then of pure bronze guns, much below the ordinary thickness, gives ample safety from bursting; while that of guns of the ordinary dimensions is so great, that it is almost if not quite impossible to burst them. To destroy them, the shortest plan is to heat them to redness, and then attack them with a sledge hammer. Under this treatment they tumble to pieces in a surprising manner.

This statement naturally leads us to the second point, how do bronze guns resist the great heat developed by the combustion of the powder?

On this point bronze is decidedly deficient; but fortunately in field guns the amount of powder burnt in each charge is small, and the scoring or erosion consequently of little importance. This scoring, moreover, is in no wise detrimental to the accuracy of the shooting, because the studs of the shell being locked hard against the driving sides of the grooves, there is an air-tight joint between them; hence no gas can pass. Thus, on examining the grooves of a bronze gun which has fired a large number of rounds you find the lands, loading side and bottom of the grooves, pitted by the heat burning the tin out of the alloy, and eroding the metal; the driving sides on the other hand are perfectly free from such pitting.

One more source of injury to a bronze gun consists in the effect of the accidental and premature explosion of a shell in the bore. Experiments at Shoeburyness with live common shells, having a small hole bored through the base so as to form a direct communication between the charge in the gun and that in the shell, prove that no material injury is done to the gun beyond a few unimportant scratches.

5. In the present state of our knowledge, the choice of a metal or combination of metals for a field gun, appears to lie between steel or steel protected by a wrought-iron coil and bronze. Circumstances may have unduly prejudiced me, but I confess I think there is nothing like bronze for the roughing of a long campaign, nothing like it for simplicity of manufacture nor for safety from bursting, nor, finally, for economy. It is curious to look back and to find that I am expressing an opinion held as far back as four and a-half centuries. One Capo Bianco, publishing in 1598, states that there were bronze guns in existence in 1418.

Bronze if bright from the turning-lathe, when exposed to damp air, soon oxidizes and gradually attains the green brown tint so much admired in antique statues. After the film of oxide has penetrated to a certain depth, practically the action on the metal ceases; though the oxide itself gets a deeper tint by time. This is the explanation of the perfect condition of antique bronze statues and other objects which have been found in certain soils after having been buried for centuries.

With iron or steel, on the contrary, once oxidation has set in, it goes on with increased vigour, and eats away until the whole mass is finally oxidized.

This is why I say bronze is better suited for the roughing of a campaign than steel.

As to simplicity of manufacture, nothing can be simpler than the casting of the block, once you have got apparatus suited to the size of your gun.

Recollect in making a comparison as regards manufacture between bronze and steel guns, you must not confine yourselves to what you have seen done in the Royal Gun Factories, you must go to Mr. Firth's or to Sir Joseph Whitworth's factories, and watch the processes there. I will not detain you with an attempt to describe these processes. I will confine myself to the statement that the art of casting steel in large masses is in its infancy, that it is necessarily expensive from the high melting point of the metal; and that in the present state of our

knowledge on the subject, it would not be advisable to attempt it in India.

As regards economy, the value of a new bronze gun of 6 or 8 cwt. is to the value of an old one in the ratio of 17 to 7. In other words, you recover £7 after using your bronze gun for a great number of years, out of every £17 you originally expended.

The value of a steel gun with wrought-iron coils of those weights when new is greater than that of the corresponding bronze gun; and when old, it is worthless, or the next thing to it.

6. So much for the metal; let me now turn to the nature and weight of the field gun for India, first confining ourselves to horse artillery.

The nature and weight of gun for employment in that or in any other country is best considered by first deciding on the following points:—

I. What weight can your teams draw at the pace you propose to go?

II. What is the least weight of projectile which will be efficient on explosion, and what is to be its velocity?

III. How many rounds do you want with the gun and limber?

On some, if not on all of these points, artillerymen will differ: hence the problem will have a variety of solutions. Permit me to give you my ideas on them.

In India we find that a team of six horses can draw from 30 to 32 cwt. at the pace required for horse artillery.

On the second point, I consider that an explosive projectile to be efficient, should not weigh under 9 lbs.

As to the quantity of ammunition with the gun and the limber, though opinions differ widely on the point, I think I shall not be far wrong in taking the same number of rounds as the 9-pounder breech-loading gun, viz. 34. At the same time, I should tell you that the French have lately increased the number of rounds with their gun and limber from 36 to 44, the alteration being due to the adoption of breech-loading fire-arms, by the infantry.

Then as to velocity: your 12 and 9-pounder breech-loading guns fired at Dartmoor with velocities of 1,121 and 1,058 feet per second. This pace is slow as compared with that of the round shot of the S.B. 9-pounder with its 1,614 f.s., or of the S.B. 6-pounder with its 1484 f.s.; the result is that up to 700 or 800 yards the S.B. guns have the flatter trajectory. It seems to me clear, then, that if we wish to improve on the present breech-loaders, we must increase the velocity. But as we cannot hope to fire a projectile of 9 lbs. with such a velocity as 1,600 feet from a horse artillery gun, let us see if we cannot manage to fire with 1,400 feet, a velocity rather less than that of the 6-pounder round shot of the horse artillery gun.

I have thus roughly given answers on the three points:—

I. 30 to 32 cwt. behind the gun team.

II. A 9 lb. projectile with a velocity of 1,400 feet per second.

III. 34 rounds with gun and limber.

Let us see what these answers will lead us to.

As at present constructed, the lightest limber, without load, weighs

10 cwt. We have further thirty times 9 lbs., and its charge of $1\frac{3}{4}$ lbs. for 1,400 feet velocity; this load, with fuzes, cartridge-bags, &c., will amount to 3 cwt.; the loaded limber, with its entrenching tools, and so forth, will thus weigh about 14 cwt.; deducting this weight from 30 cwt., the lowest limit of the total weight above laid down, will leave us only 16 cwt. for the gun and carriage.

Let us next compare the initial velocity of recoil of such a gun on its carriage firing a 9 lb. projectile at a rate of 1,400 feet per second with that of the 12-pounder breech-loading gun of the Service. An easy calculation gives the former as 7 feet per second, and the latter 6·2 feet per second.*

The recoil with the 12-pounder breech-loading gun at 6·2 feet per second is lively, and I think should not be much exceeded for both convenience in service and endurance of the carriage. 16 cwt. is then too light for a velocity of 1,400 feet with a 9 lb. projectile.

Taking, then, 6·2 feet per second as about the highest admissible limit, we can determine the weight of the gun and carriage which will project a 9lb. projectile with a velocity of 1,400 feet. Calculation gives us 18·0 cwt.†

This weight added to that of the loaded limber, 14 cwt., will give a total of 32 cwt.

If, then, you wish to have a gun with which errors in estimation of the distance are of less importance than with your present guns; if you want a gun which shall give you a more grazing fire than your present guns, approaching closely or being equal in this respect to the fire of the old smooth-bore guns up to 800 yards, and beyond that range much better; if, I say, you want these advantages, you must increase the velocity of your projectiles as much as possible; and this with a velocity of 1,400 feet involves a weight of gun and carriage of 18 cwt., and a total weight behind the gun-team of 32 cwt.

Cannot some of the weight of the *limber* be got rid of?

After a good deal of consideration and inquiry, I am reluctantly compelled to believe that no very great diminution is feasible without injury to the efficiency of the system.

7. We have, then, 18 cwt. for the weight of the gun and carriage. What is to be the weight of the gun itself? It must be mainly decided by the weight of the carriage. If the latter can be brought down to 10 cwt., and yet have adequate strength, the gun may be

* 9-pr. M. L.:—

$$\underset{\text{f. s.}}{x} \times \underset{\text{cwt.}}{16} \times 112 = \underset{\text{f. s.}}{1400} \times \underset{\text{lbs.}}{9}$$

$$x = 7 \text{ feet per second.}$$

12-pr. B. L.:—

$$x \times 20\tfrac{3}{4} \times 112 = 1239 \times 11{\cdot}75$$

$$x = 6{\cdot}2 \text{ feet per second.}$$

1239 f. s. was the velocity of the 12-pr. B. L. with the slack pressed powder. Vide Handbook for Field Service, 1867, page 322.

† $\underset{\text{f. s.}}{6{\cdot}2} \times x \times 112 = \underset{\text{f. s.}}{1400} \times \underset{\text{lbs.}}{9} \qquad x = 18{\cdot}1 \underset{\text{cwt.}}{}$

8 cwt. That carriage must be strong enough to withstand the furious jolts it is subject to behind a team rushing to the front at a gallop; at the same time it must be recollected, that the heavier the gun, the less the carriage will suffer in firing. The best possible ratio of weights of gun and carriage is a nice point, which only long experience can decide. I am well satisfied so far, that in the breech-loading guns of the service, the guns should be heavier and the carriages lighter, and that the ratio I have proposed is far preferable.

8. Finally as to calibre. It has been found that to get the best shooting, the shell should be between two and three calibres long; at the same time, to be efficient when burst, it should have adequate capacity for containing bullets, segments, and powder. If you take 3 inches as the calibre for a 9 lb. projectile, you get very formidable segment and shrapnel, with, I think, sufficiently powerful common shell and case-shot. If you take a larger calibre than 3 inches, the two latter projectiles would have a larger capacity, but the shooting of the explosive projectiles would be deteriorated. If you go below 3 inches, the capacity of the explosive projectiles would be lessened with perhaps a slight gain in shooting. Small variations above and below 3 inches would probably make little difference, but if you were to go to 3·5″ or 2·5″ for a 9 lb. projectile, I think you would be wrong.

As an instance in point, the French field gun has a calibre of 3·4 in., and weighs 6½ cwt.; it fires with a velocity of 1,066 feet per second, and complaints are very justly made of its high trajectory.

9. The gun that I think we should adopt for the Horse Artillery in India is a gun of about 8 cwt. of 3″ calibre, with 34—9 lb. projectiles, with the gun and limber, and a total weight of 32 to 33 cwt. behind the team. This is the gun recommended by the Committee on Field Artillery Equipment for India.

The main points, it appears to me, on which this recommendation should meet with the approval of thoughtful artillerymen are:—That on this system you have a sufficient number of projectiles with a gun capable of projecting them with a very high velocity, involving a total weight behind the gun-team quite within the recognized limits for horse artillery.

10. I have prepared a table from various authorities, chiefly from Major Roerdansz'* pamphlet, giving the principal weights and dimensions of various horse-artillery guns and their equipment. It is instructive to examine how the artillery of the Powers of Europe differ as to the armament of that branch. The French and Austrians agree very closely; the gun of the latter being founded on the former. The English and the Prussians are in many respects alike, but the latter carry the largest number of rounds with the limber of all the artilleries of Europe, and are therefore more independent of their wagons. The Russian and the Indian gun systems are the absolute antithesis of each other.

The Russian gun fires with a high trajectory, the Indian with a low trajectory. It appears to me that we have the best of it, on the whole.

* Das gezogene vierpfündige Feldgeeschütz v. R. Roerdansz, Berlin, 1865.

TABLE OF THE PRINCIPAL DIMENSIONS AND WEIGHTS OF VARIOUS HORSE-ARTILLERY GUNS AND THEIR EQUIPMENT.*

	Prussian.	English.	French.	Austrian.	Russian.	Indian.
Weight of gun .... cwts.	5·4	6·5	6·5	5·2	6·4	8·1
Calibre ..... inches	3·1	3	3·4	3·17	3·4	3
Weight of common shell (s) ..... lbs.	9		8·5	8·9	8·	12·5	9
Weight of charge of gun (p) ..... lbs.	1·1	1·125	1·21	1·1	1·35	1·75
Ratio $\frac{p}{s}$	$\frac{1}{8·1}$	$\frac{1}{8}$	$\frac{1}{7·4}$	$\frac{1}{7·3}$	$\frac{1}{9·3}$	$\frac{1}{5·1}$
Initial velocity, feet per second	1184	1058	1066	1093	?	1381
Weight behind gun team ..... cwt.	30·5	32·0	25·8	23·6	24·4	33·5 34·1
Weight per horse in gun team ..... cwt.	5·1	5·2	6·4	5·9	6·1	5·7
No. of rounds in limber and with gun	49	34	44	39	18	34 40
No. of rounds per gun in limber and wagon	157	124	156	156	130	124 148
Diameter of wheels .. feet	4 5	5	4·7	3·5 4·4	4	5

COMPARATIVE PRACTICE TABLE OF HORSE ARTILLERY FIELD GUNS.

	Yards Range.	Elevation.
		° ′
4-pr. French	2000	6 47
„ Austrian	„	6 47
„ Prussian	„	6 24
9-pr. English breech-loader	„	6 1
12-pr. ditto	„	5 20
9-pr. Indian muzzle-loader	„	4 22

11. I am aware, however, that some Officers do not appreciate the value of a great velocity, and consequently of a flat trajectory, as highly as I do; indeed, I am told it has been seriously proposed to adopt a gun, ordinarily carried on a mule's back, the 7-pounder of 146 lbs., as the armament of the horse artillery in preference to this 9-pounder of 8 cwt. This proposition needs only to be stated to an artilleryman to carry its condemnation on the face of it.

But if my hearers of the Artillery will pardon my entering into a few elementary questions of their craft, I will endeavour to put this

* A more detailed table will be found as an Appendix.

matter as clearly as I can to those who have not turned their attention to the subject.

The horse artillery gun is chiefly intended for firing at troops with projectiles, containing either bullets or segments, which are released from their envelope by the bursting of the charge. This charge is just strong enough for that purpose, and yet not strong enough to give the contents of the projectile *much* lateral spread. Further, for these bullets or segments to fly any distance and to have sufficient force to kill a man, the projectile at the moment of bursting must have considerable velocity.

Again, if projectiles would only fly perfectly horizontally through the air, there would be no difficulty in hitting an object at every round; unfortunately, that pestilent gravity persists in acting on the projectile; thus the shorter time gravity can act on the shell while it is flying from the muzzle to the point hit—that is, the greater its velocity—the closer the path of the projectile approaches the straight line, and the easier it is to hit the object aimed at.

If, now, we compare the 7-pounder gun with the 9-pounder muzzle-loader, we find that the shell of the former leaves the piece with a velocity of 672 feet per second, while the initial velocity of the latter, with R. L. G. powder, is 1,381 feet per second. The 9-pounder shell, after flying 2,000 yards will be still going at a considerably higher rate than 672 feet, the initial velocity of the 7-pounder.

It will be seen that the 9-pounder shell starts with more than twice the velocity of the 7-pounder; the shell travels faster from the muzzle to the point hit; gravity having all the less time to act on it, the chances of hitting are increased *pro tanto*. While the bullets or segments of the 9-pounder shell, when released after a flight inside the the shell of about 2,400 yards, travel at the same pace as those of the 7-pounder shell if burst at the muzzle.

I need hardly remind you that a range of 2,400 yards will cover the depth of any battle field.

I think I have shown that any comparison between these guns as to efficiency, is vastly in favour of the 9-pounder of 8 cwt.; and as I have shown, its weight is quite within the power of horse artillery teams.

12. As to the field batteries, what should be the nature of the gun?

I think it a good plan to see what others have done in this matter. The Prussians have two field guns termed the 4- and 6-pounder, which fire 9 lb. and 15 lb. projectiles—I will call them by their English denominations—with charges of $\frac{1}{9}$th and $\frac{1}{11}$th respectively, and consequently with high trajectories as compared with the Indian gun, which fires with a charge of $\frac{1}{4}$th. With reference to these pieces, the Prussian "Officers' Hand-book" states that:—"The 9-pounder, as "regards practice, is in no way inferior to the 15-pounder; but it is "obvious that an individual 15-pounder projectile must do greater "damage on any fixed object which it may strike, such as a house, a "wall, &c., than the 9-pounder. For this reason, to cannonade such "an object, the 15-pounder would be preferable; whilst against troops, "generally speaking, the one calibre has no advantage over the other. "The sole advantage of the 15-pounder is the greater moral effect it

"has under certain circumstances. The advantages the 9-pounder has
"over the 15-pounder consist chiefly in the larger supply of ammuni-
"tion, whereby the former is more independent of its wagons.
"Another advantage lies in the fact that its pace is faster, and can be
"longer kept up."

According to this view, the Indian 9-pounder will do all that is required of a field battery gun in the way of man-killing. I am satisfied that had the Prussians introduced their 9 pounder before the 15-pounder, instead of the reverse, the 15-pounder would never have existed.

For the horse artillery and ordinary field batteries then, the Indian Committee have recommended only one gun—the 9-pounder rifled bronze gun of 8 cwt. Permit me to draw your attention to a very important bearing of this recommendation. It is the unity and simplicity of armament inherent to such a system which will facilitate the supply of stores, and render that supply economical.

13. As to facility, take the battle-field. A battery of artillery obstinately engaged is running short of ammunition, or has a shaft or wheel broken. The first wagon met with, whether belonging to the horse or field artillery will furnish exactly what is wanted. Or, to take a time of peace; two batteries relieve each other, one of horse the other of field artillery: a subtraction of stores from the one or an addition to the other will complete the equipment. The neighbouring arsenal has only one species of stores for horse and field artillery: thus there can be no confusion, no mistake. I leave you to compare such a system with the S.B. field artillery with its four calibres!

Then think of the distances we have to deal with in India. As the crow flies it is about 1,800 miles from Peshawur to Cape Comorin, and about 1,300 to Calcutta; while from Cape Comorin to Kurachee is about 1,400 miles. Now if you will recollect that roads and rivers do not run as the crow flies, you may form some idea of the distances stores have to travel. I think then, that in India of all countries, unity and simplicity of armament are most desirable, and we have both, on the proposed system, developed in a very high degree.

Unfortunately, however, I am obliged to confine these advantages to the horse artillery and *ordinary* field batteries.

14. There remains the want of ordnance for the attack of fortified villages, entrenchments and the like. For this purpose I would have a 20-pounder howitzer and a 20-pounder mortar, both rifled. Neither of these pieces are yet in existence; but the S.B. 9-pounder can easily be converted for the one, and I see my way pretty clearly to the other with a weight of $2\frac{1}{2}$ cwt. The latter piece, if it can be got to shoot well—and I believe this to be quite feasible—would likewise be invaluable towards the end of a siege.

I would arm a few batteries with the howitzers. They *must* move slowly, owing to the weight of the equipment; but they would not be wanted until a fight was well developed, and they would rarely change position. I would further arm a few garrison batteries with rifled field mortars at the opening of a campaign.

The remainder of the field batteries I would arm with the 9-pounder M.L.R. gun.

15. To the advocates of a 12-pounder I would commend the words I have quoted from the Prussian Hand-book.

Perhaps some of my hearers who may have been in the Mutiny in India may object to me, that this 20-pounder howitzer will not replace the 8-inch mortar or howitzer of the Indian heavy field batteries. I do not pretend for one moment that it will; but it will handsomely replace the 24-pounder howitzers of the light field batteries: it will do more than this—I speak advisedly—it will be at least as efficient as the 18-pounder gun of the Indian heavy field batteries in opening a breach. It will thus compensate for the somewhat deficient common shell power of the 9-pounder M.L.R. batteries.

It will be recollected that no army goes a-field in India without a siege train of some sort. Let that siege train have the best and most powerful guns, howitzers, and mortars that you can give them, with a maximum weight in the largest gun of 50 cwt.—the weight of the 24-pounder siege gun. If you have a small fort to take, detach a portion of your siege train. But dragging about 18-pounder guns, 18-inch howitzers, and 8-inch mortars over a parade ground by elephants, drilling the battery as you would a field battery with all its minutiæ, appears to me to be an exhibition calculated to raise a smile.

Again, many would have a couple of howitzers with each field battery, for they say that just when you want your howitzers, they would be miles away. You would be in the position I once had the misfortune to be in, when we unlimbered our 6-pounder horse artillery smooth bores against the stout stone-walled fort of Wudnee, at the opening of the Sutlej campaign. I am happy to be able to add that we judiciously refrained from firing, and that the fort was evacuated during the night when we were all in bed.

16. But to return to the howitzers: there are, I think, insuperable difficulties in the way of mixing up the howitzers with the 9-pounder rifled guns. We all agree, I think, that we cannot have a really efficient common shell for field purposes much smaller than a 20-pounder with a bursting charge of about $1\frac{1}{2}$ lbs. The piece must really be a howitzer, not a mortar on wheels, for it must do a little in the way of homicide as well as fire into or over parapets, at houses, &c. We must consequently have some segment and Shrapnel shells. For these to be efficient, we must fire with a charge of at least from $\frac{1}{15}$ to $\frac{1}{10}$ of the weight of the shell. Such a charge behind a 20-pounder shell involves considerable weight in the piece—I think not much under 10 cwt.—as it is to fire at high angles, lest we smash our carriages to pieces.

But this is not all. You must recollect that this 20-pounder shell weighs more than two of your 9-pounder shells; and thus, if we associate the 20-pounder howitzer with the 9-pounder, we can only carry with it less than half the number of rounds that we do with the latter. This would be a serious loss to suffer, and in a long campaign I think you would regret your reduced supply of ammunition. I think most of my hearers will allow that the association is unadvisable.

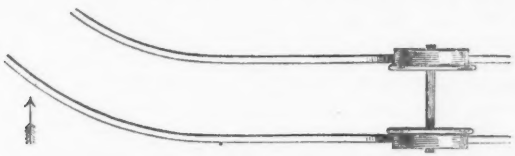
But has the reverse no advantages? Prussia, when armed with smooth-bores had distinct howitzer batteries, and within my own ser-

vice, I recollect all the 24-pounder howitzers in the Army of the Sutlej being collected into one battery at Sobraon in 1845. I merely throw out the thought for your consideration.

17. I must now return to the 9-pounder, and will say a few words about its rifling and the fit of the projectile. You will recollect that I mentioned that the cast-iron of the projectile should not come in contact with the gun-metal of the bore. The depth of the groove of the Indian gun is $\frac{11}{100}$ths of an inch, and the projection of the stud is $\frac{13}{100}$ths; deducting one from the other, we have a clearance of $\frac{2}{100}$ths of an inch between cast-iron and bronze.* Up to about 2,500 rounds fired from one gun tried by the Indian Committee, the impressions show that there has never been any contact between the hard and the soft metal. When, however, the grooves at the seat of the shell have been burnt out by the powder to such a depth that the top of the stud can no longer touch the bottom of the groove before the projectile is centred, then, of course, contact takes place between cast-iron and bronze, and the gun soon becomes unserviceable.†

Before a single round was fired, I convinced myself that what was clear in the afore-mentioned figures as to the isolation of the cast-iron from the bronze, was carried out in fact. A lamp was put into the bore, and then a shell. On looking into the bore I saw a circle of light all round the shell, saving where it was interrupted by the studs. I knew then that all was clear. The drawing will give you some idea of the appearance.†

As to the centering. Supposing you are watching a railway train going away from you along a line of rails perfectly straight for a cer-



tain distance, and then curving away to the right. The most ordinary observation or thought would convince you that when the train comes to the curve, the flanges of the near or left wheels will rub against the inner edge of the rail they run on; thus the *near* rail will divert or drive the train to the *off* side.

Now, turning to guns, suppose you cut the breech off a rifled gun, so as to be able to look through the bore;‡ that the rifling has a right-handed twist, and that the lowest groove, as in the Indian gun, is immediately below the axis of the piece at the bottom of the bore; if you follow the course of this groove, you will see it ascend the left

* Vide Figs. 1 and 2 where the shell is shown in section in the gun, excentric after being rammed home, and centred as it passes along the bore on its exit, the gun metal of the bore being in neither case in contact with the gun-metal of the piece.

† Vide Fig. 2. ‡ Vide Fig. 3.

side of the bore, advance round over the top, and make its exit at the muzzle on the right side, after having made in the Indian gun, two-thirds of a revolution. The groove, you observe, has been constantly turning in the same direction as the hands of a clock. Now, if we put a studded shell into the bore, the grooves will of course force the shell to revolve in the same direction. But if you could watch more closely, you would see that it is the side of the groove which is opposite to the direction of revolution which drives the stud round, just as the *left* rail, in the illustration I have taken, drives the train to the *right*, where the line of rails curves in that direction. We see, then, that one side of the groove does all the work in driving the shell round. Now, if that side were perpendicular to the bottom of the groove, it is true it would drive the shell round; but as the studs to enter the grooves must have some play—that is, the diameter over the studs must be less than the diameter over the grooves—there is no reason whatever why the shell should not be hard jammed towards one stud, the whole of the play being over the others. Instead, however, of the driving side being perpendicular to the bottom of the groove, if we make it oblique to the radius, and if we make the driven edge of the stud to conform to it, the rotation of the shell, or rather the force which causes it to rotate, will compel the studs to ascend the inclined planes of the driving sides of the grooves until the shell is firmly centred. If we could only centre the shell after loading and before firing, that is to say, bring all the driven sides of the studs against the inclined driving planes of the grooves, there would be much less damage done to the first foot or so of the grooves than actually takes place. For observe, on this system when the shell is loaded, it is loose in the bore and grooves; but when the powder explodes behind it, the shell is sent forwards by a tremendous force impelling the studs against the driving sides of the grooves. This causes considerable wear for some short distance in front of the shell; but as there are some three or four feet of grooving uninjured in this way, the shooting is unimpaired for a great number of rounds.

In the Austrian system,* which is in principle precisely like that I have described, the whole of the groove is a curved inclined plane. And by way of locking them into a centrical position, the shells have warts or drifts at the nose which fit into a bayonet-joint on the sheet-iron flange of the rammer-head. As soon as the shell is set home on the powder, the loadsman turns the staff of the rammer to the right and thus centres the projectile.

I am by no means satisfied that this centering before firing could not be managed with our muzzle-loading shells. But the endurance of the guns is already so great, that it seems hardly necessary to complicate the loading with even this trifling addition. The truth is that, thanks to the admirable workmanship in the Royal Arsenal, the shells are now made with a clearance between the sides of the studs and the grooves of only $\frac{1}{100}$th of an inch; thus the driven side of the stud must be brought in contact with the driving side of the groove almost instantaneously.

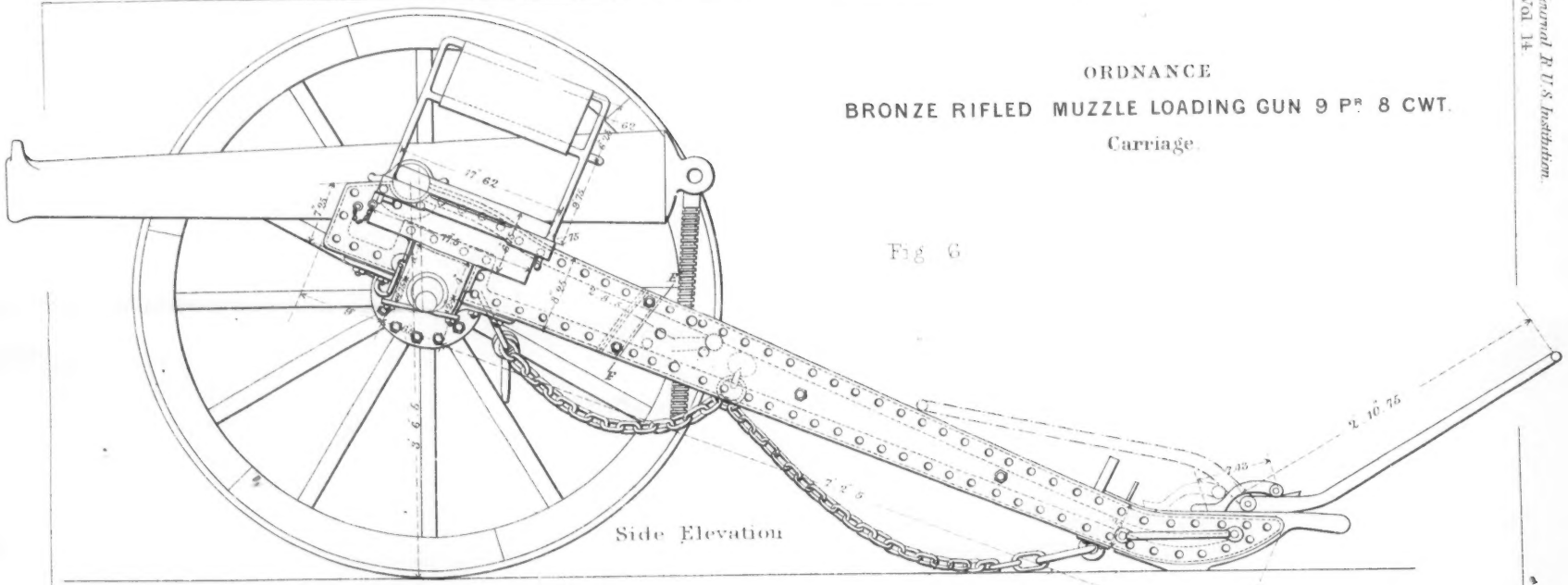
* Vide Fig. 4.

ORDNANCE

BRONZE RIFLED MUZZLE LOADING GUN 9 Pr 8 CWT.

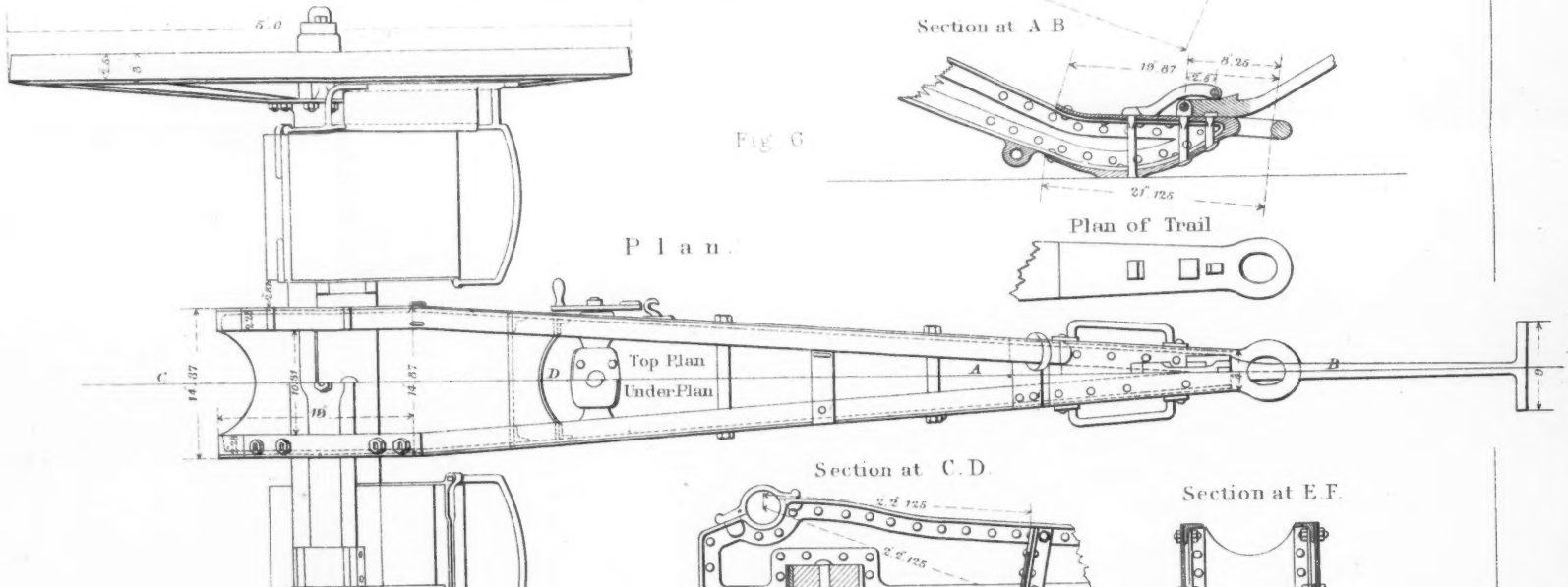
Carriage.

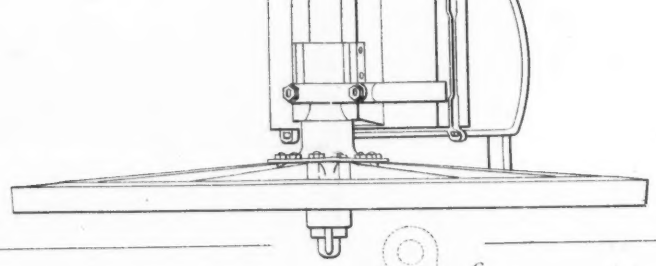
Fig 6

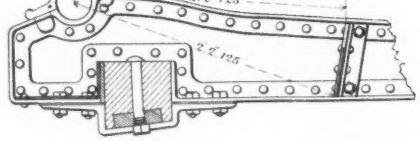


Side Elevation

Fig 6





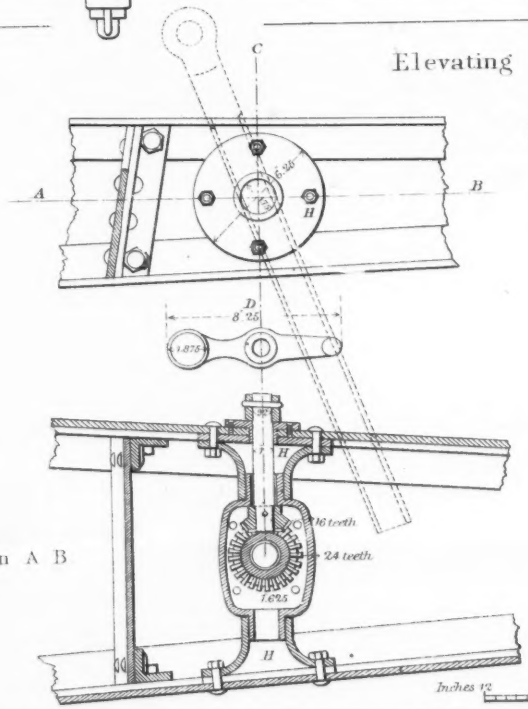


Scale.

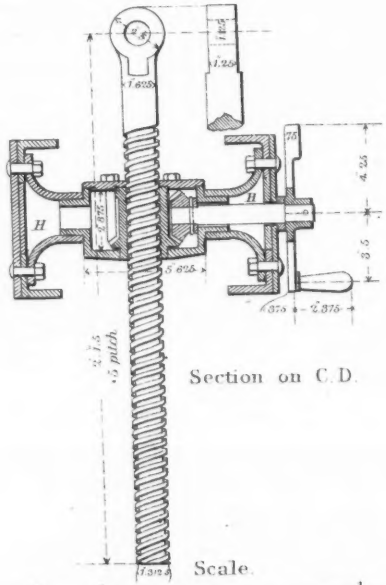
Inches 12 9 6 3 0 1 2 3 4 Feet

Elevating Arrangement.

Fig. 7.



Section on A B



Section on C D.

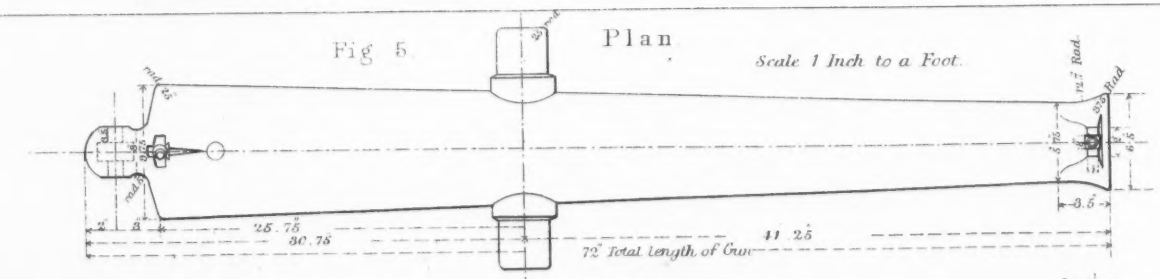
Scale.

Inches 12 9 6 3 0 1 2 Feet

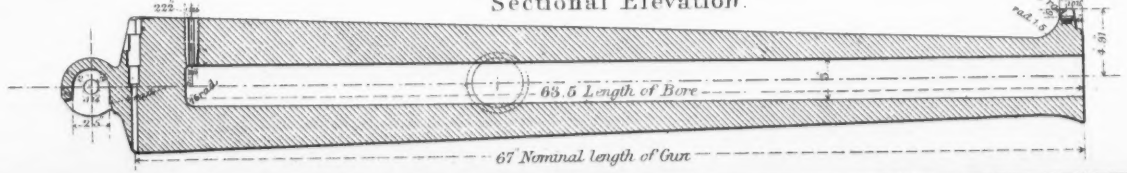
Fig 5.

Plan

Scale 1 Inch to a Foot.



Sectional Elevation.



J Jobbins

Pl. XVI.

18. Let me now give you a few details of the bronze muzzle-loading field 9-pounder gun adopted for India.

The gun weighs about $8\frac{1}{8}$ cwt.* Its length of bore is 63·5 inches, its calibre 3″; its breech preponderance is about 8 lbs. The rifling is of the French form, slightly modified in size but not in principle; the oblique inclined plane forming the driving side of the groove is at 110° to the radius. The projectiles weigh 9 lbs. They are three in number. I. Shrapnel containing 63 bullets of 18 and 34 to the lb. II. Common shell, containing $7\frac{1}{2}$ oz. of powder. III. Case-shot, containing 113 one-ounce hardened lead bullets. A segment-shell of the same weight is to form part of the equipment as soon as a trustworthy concussion-fuze can be produced. This matter is left in such good hands, that there can be no doubt we shall shortly be in possession of a projectile for long ranges which can be fired as readily as case-shot.

The charge of powder is 1 lb. 12 oz.; the nature of the powder being as yet undecided. The initial velocity with R.L.G. powder is 1,381 feet per second, and with a special powder made at Waltham Abbey, it is within one or two feet of 1,400 feet per second.

The accuracy and uniformity of shooting of this gun is, I think, remarkable. This short table will give you a fair notion of it:—

Elevation.	Mean Range.	Mean Difference of Range.	Mean Reduced Deflection.
Degrees.	Yards.	Yards.	Yards.
2	1176	14·2	0·5
3	1552	17·1	0·9
7	2665	18·9	0·8

This means that at 3° of elevation if you were to fire 100 rounds, 50 shells would be found to have fallen 17 yards short of or beyond the mean range of 1,552 yards, and $\frac{9}{10}$ths of a yard in width right or left of the line of fire.

As to rapidity of firing, 50 rounds have been fired in seven minutes; and as to rapidity combined with accuracy, 50 rounds were fired in 13 minutes, making 27 hits in a 9-feet target at 1,000 yards. Further, 140 rounds were fired from one gun without stopping, at the rate of three rounds a minute, that is continually for three-quarters of an hour. The metal became so hot as to boil water.

The shrapnel shell, fired at a column of troops, represented by targets 54 feet wide by 9 feet high, in four ranks 20 yards apart, made 48 hits *through* 2″ boards at 1,200 yards, 40 through at 1,600 yards, and 10 through at 2,000 yards. The case shot, fired at two rows of the same targets, 50 yards apart, at 300 yards, gave 6·5 hits through 2-inch boards; 11·9 lodged, and 3·3 struck, in total 21·7 hits per round.

* Vide Fig. 5.

The sighting of the gun is central, and both muzzle and breech sights are completely protected against injury. The plate carrying the notch in the breech-sight is capable of lateral deflection. This refinement will scarcely be necessary in firing at troops; but it may be required in certain cases where great accuracy is desirable, such as firing at a single gun, at the pillars of a house, or the voussoirs of an arch, &c. The tangent scale is set in at an angle of 1° 30′ to the left of the vertical to correct the deflection or drift up to 1,500 yards due to the pitch of rifling and velocity.

The venting is that of the smooth-bore guns, excepting that the vent is vertical, striking the axis of the piece at 0·6″ from the bottom of the bore. The object of a return to the old venting is to ensure the whole of the cartridge bag being blown out at each discharge. The Indian Committee tried several patterns of sponges calculated to fetch out *débris* of cartridge; but this venting left them nothing to do in this respect.

19. The gun-carriage is chiefly of iron;* the trail is composed of two plate-iron brackets, stiffened with angle-iron, connected by through bolts, and ending in the trail-eye. The axle-arm is not steeled so as to be suited to the gun-metal pipe-box of the nave.

The wheels are of the Madras pattern, so well known as not to need description.

The fittings of the ammunition boxes are of the simplest nature, and are so contrived that when the lid is closed, each shell is held fast in its place by wooden compressors in contact with the lid.

Right and left of the gun are two boxes, the lids of which can be made available as seats for two gunners with the *field* batteries, while two are carried on the limber, and two more on the off horses of the team; so that the gun can go into action independently of its wagon, with its gunners fresh for their work.

In the near box are three case-shot and three charges, with priming irons and tube-pouch. In the off box it is proposed to place a range-finder and one round of case-shot. The limber contains 30 rounds, but accommodation is provided for 36.

The weight dragged by the gun-team, with men dismounted, will be about 33½ cwt.; that is one and a-half cwt. heavier than the Royal Horse Artillery 9-pounder breech-loader, and about the same weight as the 6-pounder smooth-bore of Royal Horse Artillery in India.

The wagon and limber contain 96 rounds, or 128 filled up, the latter being interchangeable at will with the gun-limber. The weight behind the team is about the same as with the gun, 33 cwt.

The forge wagon differs little from that formerly in the service, with the exception that iron is brought into use as much as possible.

With regard to the endurance of the carriages in firing, one has had fired from it some 4,000 rounds. For 500 rounds, the wheels were lashed to posts to stop the recoil. The carriage at this moment appears to be as good as when new.

The gun-carriage has met with the highest approbation of all who have used it, and I believe all who have seen it. It was designed in

* Vide Fig. 6.

the Royal Carriage Department at Woolwich, and appears to me to reflect the greatest credit on its designer.

The adoption of this carriage for India relieves us from a very great difficulty. We have magnificent wood in that country, but it is getting scarce, the scarcity being due to the introduction of railways and to the forests having been neglected. The timber for the manufacture of the carriages had to be stacked in covered sheds for several years before use. Of the timber thus stored a great deal split in drying to such an extent as to be useless for the larger portions of the carriage, viz., the trail-beam and naves. Thus, when a stress came as in and after the Mutiny, the main difficulty in equipping the batteries with their carriages was the want of seasoned wood.

With the new carriage, the largest piece of wood required is for the axle-bed, which acts as a mere cushion: its soundness is not vital to the efficiency of the carriage. The spokes, felloes, and the slight woodwork of the limber will not be, under almost any circumstances, difficult to supply in India; for it is easy to get a small piece of sound wood, when it might be impossible to find a large piece of the same quality.

Again, the open trail of the iron carriage permits of the passage of Sir Joseph Whitworth's* admirable elevating-screw. With the wooden carriage you were compelled to bore an oval hole of very considerable size through your beam, at the very point where it was weakest. Around this lamentable hole, you bored four smaller holes for the holding-down-bolts of the socket of the ball-nut of the elevating-screw. This defect of construction is avoided in the bracket-trail.

Once more, we are subject to the most dreadful pest of white ants in India, against which there is only one effective precaution: it is to move all articles made of wood every day. With an equipped battery this amounts to mere inconvenience; you have to look after your wagons in your sheds. But in arsenals and manufactories, the difficulty is a very serious one. In our new carriages, iron being largely used, those who have charge of stores will have all the less to fear.

20. Let me now succinctly compare this muzzle-loading 9-pounder with the breech-loaders of the service.

I have no doubt in the world, that a gun on the Armstrong breech-loading system, firing 9-pounder shells with a charge of $1\frac{3}{4}$ lb., and weighing 8 cwt., could be made, which would equal the 9-pounder muzzle-loader bronze gun in accuracy, and in flatness of trajectory; but there can be no manner of doubt that the breech-loaders of the service are on both points inferior to it.

The adoption of the latter system entails the following heavy list of complications:—

1. Detonators to the fuzes, which are liable to injury by climate or jolting, despite elaborate packing arrangements.
2. Breech-screw, with tappet lever and keep pins with reserve.
3. Vent-pieces with reserve.
4. Facing implements.

* Vide Fig. 7.

5. Armourers and special tools.
6. Lubricators and tin cups.
7. Lead-coating to shells involving India-rubber discs in the boxes.
8. Browning and greasing the gun.

These complications may or may not form serious objections to the breech-loading gun in Europe; but for India, in my opinion, there is no doubt in the matter. There we have an atmosphere which in a short space of time alternates between that of a heated oven and a steam-bath. Expansion, contraction, rust, mildew, and so forth, try war stores by tests ten fold as severe as any they are subject to in Europe. Again, the source of supply is so distant—if we were to rely on England, as perforce we must with the breech-loading system—that the country might well be lost before fresh supplies could reach us, even supposing them unintercepted on the high seas. On the other hand, large stores might be laid in, in fortified arsenals, so as to meet all possible wants.

Independent of the consideration of the effect of the climate on such stores, the recollection of Delhi in 1857 reminds us that we might again be putting arms into the hands of our domestic enemies for our discomfiture; as the first process in every rebellion or revolution is to seize a depôt of arms. A country is thus all the safer the fewer arms she has in dangerous districts beyond her own immediate wants.

Manufacture in the country is then the best security. I shall probably be told that for a campaign you must trust to your stock in hand and not to manufactories. I reply that a campaign such as we had in India during the Mutiny, would denude most of your arsenals, and that while the troops are fighting in the field your manufactories, working night and day, should, if properly organized, be able to supply the arsenals nearly, if not quite, as fast as they issue stores. Thus, instead of being exhausted at the end of a campaign, you would be nearly as strong as ever in *matériel*.

On the other hand, what advantages does the breech-loading system hold out to us in India? I confess that the only one that I can see is assimilation with the Royal Artillery at home; and this advantage I humbly hope and trust we shall soon have by the universal adoption of the muzzle-loading system.

21. Let me now give you in two words a *per contra* list of the advantages of that system:—

1. Simplicity throughout the equipment, involving the possibility of manufacture in India.
2. Stores little liable to injury from the climate of that country.
3. Economy.

These are the main advantages, though there are many others of a minor and less general nature.

22. Before concluding, I do not think it out of place now that we have got a gun for India, to direct your attention to the question of keeping it. Let me give you an idea of how guns are taken in action in these days of breech-loading small arms.

"At Lipa, near Sadowa, 10 Austrian guns fell into the hands of the

"Prussians, their teams having been shot down from a distance "almost entirely by a section of the Fusileers of the Guards.

"Out of the 113 pieces taken from the Austrians in actual fight, 108 "were taken by infantry, and almost all by swarms of skirmishers. "The method of attack was always the same. The skirmishers got "under cover within range of their rifles, and thus knocked over men "and horses; they then charged the battery, generally speaking "abandoned by its infantry escort, and with three-fourths of its "horses down, the battery fell an easy prey."

Now this Austrian artillery behaved heroically, it fired case-shot to the last, and covered the retreat of the army.

That is to be our field artilleryman's fate, unless we are better backed than were the gallant Austrian gunners!

But how is this backing to be managed?

The fire of modern small-arms is deadly at 500 yards; at 800 yards it is formidable; and even at 1,200 yards with the Martini Henry it is something serious.

A flat trajectory will avail you much; but if your opponents of the infantry are under cover, even at these short distances your guns will do so little, that the expenditure of ammunition would not be justifiable.

What is to be done then with these skirmishers?

Every battery when engaged should have a permanent escort—not only theoretically as at present, but practically—and that escort must on no pretence whatsoever abandon its charge as was the case with the Austrians.

If the enemy's skirmishers advance against a battery, they must be met by skirmishers, especially on their flanks. If men and horses are being shot down by light infantry, one of two things must be done: the battery must retreat at once, or the escort, strengthened if necessary, must drive back the skirmishers.

Thus far I am clear; but suppose the battery has to advance 1,000 yards at a trot and gallop, where would be your infantry escort?

I see nothing for it; but to detail a cavalry escort to cover the advance in extended order and to retire by the flank as soon as the battery has got into action, the cavalry being relieved by the infantry escort. This is complicated, but something of the sort appears inevitable.

It would seem that now more than ever, a battery in action must be dry-nursed. That the General under whose orders it acts, should be impressed with the indubitable fact, that a battery of field artillery is, like gold, a very valuable possession; and that in proportion to its value, it is all the more likely to be robbed from him, unless he guards it with all the care that he bestows on his purse.

In my own experience of service, escorts to batteries were often told off, but they invariably were left behind on the advance of the battery, and rarely came up to it again, being ordered off elsewhere and otherwise employed. This must no longer be permitted, on pain of the loss of our guns.

23. In conclusion, casting a glance back at our smooth-bore field

artillery and to its advantages in ricochet, I cannot regret it in any respect but one, viz., its more powerful case-shot fire. In all other respects, the rifled gun has the advantage. When the smooth-bore round-shot hit an object 100 feet long by 6 feet high once in every four rounds at 1,000 yards, one-half of which was by ricochet, the Indian gun would hit *at least* three times out of four rounds. It is very well to say the round-shot will go bowling on and hit half-a-dozen objects before it comes to rest. I ask, is it better to hit the object aimed at three times out of four, than to miss it as many times, and to trust to chance that something else may be in its way before its course is finished?

I have thus given you some idea of the field gun for India, and in taking leave of the subject, venture to express before you my fullest confidence in the system which has been adopted. As far as my lights go, the gun compares favourably with any existing field gun; its endurance ample, its uniformity of range and accuracy of direction admirable; its simplicity great, and its trajectory, the flattest that has come to my cognizance. The bronze gun and its iron carriage are suited to India, and their manufacture to the artificers we have at our disposal. They have, however, two great tests to undergo, more severe than any they have been put to at Shoeburyness, viz., time and actual employment on the battle-field. I have no doubt of their successfully enduring both those tests.

I beg to thank you for the attention you have been good enough to pay to my feeble exposition of "The Field-gun for India."

APPENDIX.

Principal Dimensions and Weights of various Horse Artillery Guns and their Equipment.	Breech-loaders.		Muzzle-loaders.		Breech-loader.	Muzzle-loader.
	Prussian.	English.	Austrian.	French.	Russian.	Indian.
	4-pr.	9-pr.	4-pr.	4-pr.	4-pr.	9-pr.
The Gun.						
Calibre ..... inches	3·089	3	3·17	3·41	3·42	3
Number of grooves	12	38	6	6	12	3
Depth „ „ ..... inches	0·051	0·045	0·175	0·113	0·051	0·11
Width „ „ ..... „	in front 0·6 / in rear 0·71	0·148	1·54	0·67	0·61 / 0·77	0·8
Length of bore rifled ..... „	59·6	.....	42·2	49·4	47·	63·5
Pitch-angle ..... degrees	3°45′	4°43′	8°30′	6°53′	4°35′	5°59′
Length of bore ..... calibres	22·5	17·5	15·	16·	17·	21·2
Weight of piece ..... cwt.	5·413	6·3	5·177	6·5	6·43	8·1
Ammunition.						
Diameter of common shell ..... inches	3·089 / 3·192	3·02 / 3·07	3·089	3·305	3·418 / 3·522	2·94
Length of nose of do. ..... „	1·86	....	3·19	2·83	2·08	3·13
Length of cylinder of do. ..... „	4·47	....	3·91	3·47	4·83	4·8
Total length of do. ..... „	6·33	....	7·10	6·30	6·91	7·93
Weight of common shell filled ..... lbs.	8·96	8·5	7·99	8·9	12·5	9
Weight of common shell bursting charge ..... oz.	5·9	5·	7·	7·	7·9	7·5
Number of balls in shrapnel	....	42	80	85	....	63
Weight of shrapnel ..... lbs.	....	9·	8·03	9·72	....	9·25
Number of balls in case-shot	48	....	56	41	40	108
Weight of case-shot ..... lbs.	6·59	....	7·94	9·73	8·43	9·
Service charge of powder ..... „	1·1	1·125	1·1	1·21	1·35	1·75
Ratio of weight of charge to shell	1 / 8·1	1 / 8	1 / 7·3	1 / 7·4	1 / 9·3	1 / 5·1
Initial velocity ..... feet per second	1184	1058	1093	1066	?	1381

Principal Dimensions and Weights of various Horse Artillery Guns and their Equipment.	Breech-loaders.		Muzzle-loaders.		Breech-loader.	Muzzle-loader.
	Prussian.	English.	Austrian.	French.	Russian.	Indian.
	4-pr.	9-pr.	4-pr.	4-pr.	4-pr.	9-pr.
Gun Carriage.						
Track ..... inches	60·24	62·	59·7	56·3	58·	62·
Diameter of wheel ..... „	61·	60·	52·5	56·29	48·	60·
Weight of gun-carriage, equipped, but without gun ..... cwt.	9·35	10·5	8·6	8·42	8·39	10·5
Weight of gun-carriage, equipped, but with gun ..... „	14·04	17·0	13·78	13·88	14·07	18·75
Rounds carried on gun	1	....	3	4	....	4
Limber.						
Diameter of wheel ..... inches	48·6	60·	43·2	56·3	48·	60·
Weight of limber, packed ..... cwt.	15·75	15·	9·86	10·1	8·95	{14·0 / 14·6}
Number of rounds in limber	48	34	36	40	18	{30 / 36}
Proportion of ammunition in limber — common shell	40	6	20	32	8	8
carcass	4	....	....	....	....	....
shrapnel	....	....	10	5	6	16
segment	....	18	....	....	....	....
case-shot	4	10	6	3	4	6
Miscellaneous.						
Weight of gun behind team ..... cwt.	30·5	31·5	23·63	25·76	24·4	{33·5 / 34·1}
Number of horses in team	6	6	4	4	4	6
Weight for each horse in draft, men dismounted ..... cwt.	5·1	5·2	5·9	6·4	6·1	5·7
Number of rounds per gun, limber, and one wagon	157	124	156	156	130	{124 / 148}
Number of men carried ..... on limber	2	2	1	....	2	2
on gun	3	....	3	3	3	....

N.B. The numbers bracketed in the column referring to the Indian gun are to be taken according to whether each ammunition box contains 15 rounds only, or is filled up with 18.

The CHAIRMAN: Has any gentleman any observations to make on this elaborate paper?

Captain HEATHORN, h.-p., R.A.: I have an observation which I hope you will allow me to make. Being an Indian gunner myself, I am very much interested in this able lecture on the new Indian gun, and there is one point in the Indian gun carriage that I should like to refer to: it is the elevating-gear, which I hear has been presented by Sir Joseph Whitworth. In the early part of 1867, before the French Exhibition, I prepared a model of a similar elevating gear, which I submitted to the Ordnance Select Committee, which afterwards went to the French Exhibition, which returned, and which is now in the Museum of this Institution. The principles of that elevating-gear are these, and they are the same as those of the Indian gun:—A vertical screw is driven up and down by a cog-wheel nut, which is made to revolve by a mitre-wheel. This nut is supported by a cradle, which swings on the carriage by shoulders or trunnions; the centres of the spindle of the mitre-wheel driving the cog-wheel nut and of the trunnions of the cradle, coincide; therefore, whatever motion the cog-wheel nut is constricted to take by the oscillating movement of the screw up and down is at once communicated to the mitre wheel, then to its spindle, which, as I have said before, has its centre coincident with the centres of the trunnions of the cradle that bear the nut; therefore nothing gets out of gearing. This, I believe, is the first time that such an arrangement was ever submitted for driving a screw at all, at least in gunnery. Mr. James, a very well-known mechanic in Lambeth, made the model, and he told me this elevating gearing was a new thing. If anybody would like to see it, the model is in the Museum. To that particular circumstance, viz., the coincidence of these centres, is due that very easy motion which is found to answer so well in the Indian elevating screw. I have tried to explain my claim to Government, but have met with no success. I have no doubt mechanics, if they will take the trouble, will see that what I say is true. An Institution of this kind is no place for inventors to come to with their claims, at least if they are claims, for reward. But if a man like myself, who all the time he has been in the Service has given his attention to the development of his profession, claims an invention, he claims something more than money, he claims the honour of that invention, if it turns out well, and I wish everybody to know that I make that claim distinctly. There is one more point which I should like to mention, alluding to the necessity for protection to horse artillery and field artillery in meeting an adverse force. I do not think Colonel Maxwell told us how horse artillery is to be provided to meet infantry skirmishers. I think it was in the Prussian campaign, to which Colonel Maxwell alluded, that the Prussian gunners were shot down to a man by the infantry skirmishers; therefore the field artillery ought to be accompanied by an infantry force. But I do not imagine that horse artillery guns could be accompanied by an infantry force, and as they will, by turning the flanks of armies, have at times to meet infantry, I shall be glad if Colonel Maxwell will tell us how those guns are to be protected.

Colonel MAXWELL: As no one seems inclined to get up, I should like to say one word upon the subject of the elevating screw. I saw it in Sir Joseph Whitworth's office in London; there was nothing new in it; I knew the whole thing perfectly. I had seen the thing in various applications dozens of times. Go down to Woolwich Arsenal, or to any factory in England, and you will see the same principle applied. In the gun carriage of Captain Scott it is applied. Sir Joseph Whitworth, I should think, would never have dared to go to the Patent Office and take out a patent for such a thing; nor can I conceive that any man would dare to do such a thing. I might as well take out a patent for putting fire under water to make it boil. I do not know who originated the idea, but I have been familiar with it for years and years.

Captain HEATHORN: May I answer that. It is not a novelty to use mitre wheels to drive a screw. It is the particular coincidence of the centre of the spindle of the mitre-wheel and centre of the trunnions of the cradle bearing the nut, that is a novelty. Captain Scott's gun carriage uses a vertical screw with bevelled wheels. That is very well. But where you constrict the nut of the lower wheel to a certain necessary movement by a screw which oscillates in a vertical plane, you must provide

that those mitre-wheels do not get out of gear. My invention is that the centre of the mitre-wheel is in coincidence with the centres of the trunnions of the cradle bearing the nut, therefore it is not like Captain Scott's method of raising and depressing his gun by a fixed vertical screw. That does not oscillate; his is a standing arrangement; there is no oscillation at all about it.

The CHAIRMAN: I am afraid if we are to go into these elaborate details, and into questions that are always extremely difficult as to priority of inventions, we shall be straying away from what is more interesting, the "field gun of India." Without a model, the question raised by Captain Heathorn is almost unintelligible.

Captain HEATHORN: The model is in the next room.

The CHAIRMAN: I know, but I would rather keep to what we have before us, the field gun of India. General Eardley Wilmot, who is here, will, perhaps, be kind enough to say a few words.

General EARDLEY WILMOT, R.A.: I should like to say a word with regard to the elevating arrangement for the gun, because I am to a certain extent responsible. I saw this arrangement in Sir Joseph Whitworth's office, and having a long acquaintance with him, I asked him if we might apply it, as it stood, to the gun under our consideration. He very kindly put it at our disposal. I submit that the Indian Field Artillery Committee is not constituted the arbiter as regards inventions. It is nothing to us whether this arrangement was invented in the time of Adam; all we know is that it was ready made to our hand, and we gladly adopted it. We do not say it was Sir Joseph Whitworth's invention, or Mr. Anybody's; all we say in our report is that we had been permitted by Sir Joseph Whitworth to adopt the elevating arrangement which was in use on one of his guns.

Colonel SMYTHE, R.A.: There is one remark I would make about Captain Heathorn's suggestion about escorts. If we have a war, I think we shall find it absolutely necessary to protect field artillery by riflemen, who shall accompany the guns in cars; there is no other way, I am certain, that field artillery can be properly used in a campaign without their escorts are carried in that way.

General EARDLEY WILMOT: I wish to add a few words with regard to the paper that has just been read. I feel a certain amount of delicacy in saying anything, having been President of the Committee of which Colonel Maxwell has been so able a member. My principal object in rising at the present moment is, that I may convey to this meeting a feeling which we all feel towards Colonel Maxwell, for the great zeal, energy, and intelligence which he has brought to bear on this question. I am aware that, to a certain extent, I am taking this duty out of the Chairman's hands, but having been cognizant of the matter from the beginning, and having had the pleasure of Colonel Maxwell's acquaintance, I cannot on this occasion help bearing my testimony to his labours; I believe no Committee has ever worked more harmoniously, or in a more friendly manner. To me, at the close of my services—for you know that when an artilleryman becomes a General, he has very little more to do, except to hide himself—it has been a pleasure to become acquainted with Colonel Maxwell and the other Officers of the Indian service. There are some points mentioned by Colonel Maxwell to which I may refer. With regard to the gun, there are many of us who for many years have considered that a muzzle-loading gun for field service is the best weapon, and who think that the *onus probandi* ought to be thrown on those who advocate breech-loading, to show in what the muzzle-loading gun fails. I am thankful, after many years' of discussion and experiment, to see that the feeling is gradually coming round to our position, not only on the grounds which Colonel Maxwell has so ably set forth, but also from the growing conviction that there is no necessity for a breech-loader for field service, either as regards rapidity of fire, accuracy, simplicity, shell power, and high angle firing. I think the artillery has gone rather in the wrong direction; in seeking for a breech-loading gun for field artillery, they were seeking for a thing for which there was no necessity; not that there is an objection to breech-loading, as such, because if a heavy breech-loading gun could be found, it might be made a valuable weapon. How far we are from it remains to be seen. At the same time a muzzle-loading gun for general purposes, being so simple and so comparatively easily made, is far preferable; and if you can by some means introduce a carriage which can assimilate itself to the result gained

in the turn-table of the service, that is to say, if the muzzle of the gun, in the act of recoil, be brought round to a convenient loading position, you would get almost everything you want. The only advantage of breech-loading is the supposed facility, not rapidity, of loading, without having to push the rammer through the port of the ship or the casemate. The Navy, we all know, have expressed themselves rather strongly with regard to the breech-loading gun. The same difficulty they find of clearing the deck or turret from smoke when the breech-piece is taken out, would be found also in casemates. When you take out the breech-piece the whole of the casemate is filled with smoke instantly, so that the gunners cannot see. With regard to bronze, there is no doubt that the present system of casting bronze, which was introduced in the year 1853, is very favourable, for it produces a metal of a much harder character than the old bronze. There is at Shoeburyness a specimen of a bronze muzzle-loading smooth-bored 9-pounder gun. This gun has fired at least 1,666 rounds. That return was taken in August, 1869; since then I have no doubt it has fired a good many more. The life of bronze muzzle-loading guns was said formerly to be 300 to 400 rounds at the most. One reason given was that the gun drooped at the muzzle, on account of the heat from firing. A long argument among artillerymen on that subject was terminated satisfactorily by an experiment which was made in the Arsenal some years ago. A bronze gun was heated up to a glowing heat in the furnace; it was taken out, balanced on a knife edge, and left there to cool. If the softness of the metal was so great that the heat of it would put it out of form, you would think that in a 13½ cwt. gun, balanced on a knife edge, there would be some deviation of the bore when the gun was cold. It was found there was nothing of the kind. The drooping and destruction of the bore entirely arose from windage. It is a curious circumstance in our service that so many were averse then to a diminution of windage. The gun at Shoeburyness was made in the Arsenal, under a certain order; it was sent there, and fired an unusual number of times. The believers in "drooping" began to wonder why this gun was not destroyed; and on examination of the papers it was found that it was made with diminished windage. But the gun was there, and those who were interested in it said, "You had better go on firing the gun." The gun is still as good as ever, and is in constant use; therefore it is clear, if the bronze will stand a charge of powder for a 13 cwt. gun, it will stand the charge of powder for a rifled gun, because the charge for a rifled gun is less. Colonel Maxwell has said something about the introduction of mortars. I confess to a particular objection to mortars. The shape is an absurd one, fit only to be seen in a museum, because mortars are inapplicable to horizontal fire. With the same weight you might have a short Howitzer, which could be applied to vertical fire just as well as a mortar. Unfortunately, up to the present moment nothing has been done in the way of howitzers, of which Colonel Maxwell has spoken. I have long advocated the use of heavy shells with field howitzers. But to return to the subject of the Committee, it is a subject of congratulation that such a Committee as this was appointed, with Indian officers upon it, and to a certain extent under the superintendence of the India Office, because, by that means the whole question has been looked at in an entirely independent manner, and we have come to conclusions perfectly independent of any preconceived notions. The Committee has been engaged rather a longer time, perhaps, than the authorities have liked; but I am sure every Officer will be satisfied that the time has not been long in which to produce an equipment almost entirely new, a gun entirely new, a carriage entirely new, ammunition, small stores, and everything connected with the gun, almost entirely new. The period occupied by the Committee was about a year and a quarter, or nearly a year and a half; not extraordinarily long, particularly when you consider how many years the whole question of field artillery has been on the *tapis*, and does not seem to be in a permanent position yet. The whole cost has been comparatively small, not exceeding £3,000 in the whole, that of the Whitworth and Armstrong Committee having been £30,000. The experiments have been kept down to the smallest number compatible with a satisfactory result. I join with Colonel Maxwell in hoping, most heartily, that what has been done for the field artillery of India will be the initiation for British artillery generally.

Major-General BOILEAU, F.R.S: Before the discussion closes I should wish to address a few observations to the meeting, not in the sense of an artillery Officer, for I would not presume to give an opinion of the qualities of the gun in that sense. But there is a point of view which I think I may be privileged to notice. It is that the introduction of this bronze gun into India will enable the Government of India to make their own artillery on the spot. That is a point of very great importance. There may arise circumstances in which it may be of the greatest importance that we should be able to manufacture guns in India, which I have no doubt, from the description given, are entirely suited to the country in which they will be employed. I may add, if the artillery service in India is not very much changed from what it was when I was there, that the gun will have on service the best possible application that a gun can have. That the gun and its carriage and ammunition can be made with ease in India, is a point the importance of which cannot be over-estimated. There is only one other point I would mention before I sit down. It is this, that in the theatre of this Institution, improvements in artillery and projectiles have been brought forward which are of the greatest interest and value. I allude to Palisser's system of guns and ammunition, to Moncreiff's gun carriage, and to Heathorn's muzzle-pivoting carriage. I can only hope, as there seems to be a certain amount of good luck attending the reading of papers in this Institution, that Colonel Maxwell, who has read a most interesting and instructive paper this evening, will also reap the benefit of this *prestige*, if there be any, and that the future will show that his ideas are sound and have been considered worthy of an extended adoption.

Major TESCHEMAKER: I should like to ask one question with regard to the material for the gun carriage. Colonel Maxwell says they are relieved from a great deal of difficulty in India by the introduction of iron. Though wood is getting scarce in India, I think iron is still scarcer.

Colonel MAXWELL: In explanation I would say at once, that what I mentioned just now was, that the adoption of iron relieves us from a very great difficulty. If you recollect, I distinctly said that wood had to be seasoned for a long period of time, to be kept in covered sheds, and that in the process of seasoning a great deal of the wood became injured. If, then, we can get out angle iron, bars, bolts, and so forth, put them into a shed, and let them be there for a dozen years, no seasoning will be required, no white ants; nothing will injure them. In a time of emergency, you cannot get seasoned wood, as we found in India, towards the end of the mutiny, when the stock began to run low. Endeavours were made on all sides to procure seasoned wood, but it was not to be had. Now, iron can be had at any time.

Colonel FLETCHER: There is a question I would like to ask, although I do so with great diffidence, not being an artillery Officer, and consequently not well acquainted with the subject. It is with regard to the composition of service batteries, whether it would not depend upon the nature of the country in which the campaign would take place. I remember in 1862 the American artillery Officers were very much in favour of the Napoleon 12-pounder gun, because they found that it was much more effective in the wooded country in which they were campaigning than the rifled field gun. Therefore I would ask Colonel Maxwell, supposing we were to have a campaign in a very wooded country, whether it would not necessitate an increase of the number of our howitzers, or the adoption of a gun somewhat similar to that used in the American campaign, namely, the Napoleon 12-pounder?

General EARDLEY WILMOT: That question would have been gladly entertained by the Indian Committee, but on referring to the Indian Government we were distinctly told that we were not to trouble ourselves about it. We were all anxious to go into that very question which Colonel Fletcher has spoken of, being fully alive to the importance of it.

Colonel E. B. JOHNSON, R.A.: I should like to answer General Boileau, and I think Colonel Maxwell will endorse what I say. The first ground on which the bronze muzzle-loader was taken up was the capabilities which India possesses of making that gun, compared with the impossibility of making the breech-loader. (Colonel MAXWELL: Quite so.) As for iron, there is as much iron to be found in India as there is anywhere else.

Mr. E. J. REED, C.B., Chief Constructor of the Navy: Although it is very late, I will

venture to say one or two words upon the subject, though I am afraid that what I say on such a subject will not be considered important. It seems to me that if the discussion were to close at this point, the paper would scarcely have justice done to it, inasmuch as Colonel Maxwell has, in the course of his paper, enunciated several propositions which appear to be of very great moment, and which I probably, in common with other mechanical persons, have listened to with great satisfaction. One is, that Colonel Maxwell has exemplified a preference for weight of gun instead of a preference for weight of carriage. My own opinion is, that the principle has to be much more developed than it has been, not only in field artillery, but in heavy artillery; and that the time is fast coming when we shall distress our carriages a great deal less than we at present distress them, by putting a great deal more weight into the gun, and making the carriage lighter. Another point that I have listened to with peculiar gratification is, that in the production of this system of field artillery for India very great importance has been attached to a low trajectory. I am almost afraid to say that, in my opinion, that question has been too much passed by in certain quarters. I view with the greatest apprehension a preference shown by any gunnery Officer whatever for a gun with a high trajectory; and I think the effort of every person concerned in the construction of guns should be directed towards the production of guns with a low trajectory. I know it is said that, for naval purposes, the unsteadiness of the gun platform is an argument against any great attempt at accuracy of fire at considerable ranges. But I think, on the contrary, that while the naval architect has the most solemn obligations laid upon him to produce the steadiest possible gun platform, that a like obligation ought to be laid upon the gunner and upon the gun manufacturer to produce the lowest trajectory, and to give the gun the best possible aim. I might possibly differ in a slight degree from the gallant Officer who read the paper in one point, because, for my own part, I should like to see a low trajectory obtained, with less dependence upon a high initial velocity. I am in favour of a somewhat smaller bore, with great velocity at great range, rather than in favour of a high initial velocity with a larger bore. If you look at the table you will see that that system of designing ordnance has not been lost sight of even in this case, because, as compared with all European systems of artillery, the accuracy and success of this gun has been secured by means of the smallest calibre, and, therefore, the lowest trajectory with regard to the powder used. I view that with the greatest satisfaction, because I am sure in field artillery, as in naval artillery, and in all other classes of artillery, there is too great a tendency to disparage the small bore, and the accuracy which results from that with proportionate charges. I think it is only fair to Sir Joseph Whitworth, into whose system I have been lately looking, to point out that, with regard to the small bore rifle, he unquestionably led the way, and I believe honestly he is no less unquestionably leading the way in artillery likewise. Nor is this true of the small bore only; on looking at the system of centring the shot, of which Colonel Maxwell gave us a lucid explanation, I always fancy that I see in that stud, with its inclined surface, tending to the centring of the shot after a certain motion has taken place, the rudimentary form of Sir Joseph Whitworth's system of polygonal bore and projectiles. I will say no more upon the paper. I thought it due to the gallant Officer who has read it to take advantage of your kindness, sir, in allowing me to say a word or two, to point out that his paper does involve a recognition of these very important principles. I for one, as a mechanical person, have listened to him with very great satisfaction on that account.

The CHAIRMAN: I will now close the discussion by asking you to give a vote of thanks to Colonel Maxwell for his very interesting and valuable paper. We have heard to-night the testimony of the gallant Officer who was President of the Committee on the Field Gun for India; and I am sure that any words that I can add would be superfluous, as that gallant Officer has had the best opportunities of judging of Colonel Maxwell's knowledge of the subject, which I am sure you must all agree with me is most minute and most elaborate. I beg to return to Colonel Maxwell our best thanks.

LECTURE.

Friday, March 18th, 1870.

GENERAL THE HON. SIR EDWARD CUST, G.C.L., K.H., &c., in the Chair.

MILITARY MAXIMS SUGGESTED, OR EXEMPLIFIED, BY THE LAST AUTUMN MANŒUVRES OF CONTINENTAL ARMIES.

By Colonel C. CAMERON SHUTE, C.B., Commanding 4th Dragoon Guards.

ADDRESSING as I do an audience many of whom possess the experience of much actual service, I would commence this lecture, which will consist of little more than mere practical remarks suggested by the tactics of a practice campaign, with two short quotations from Hozier's "Seven Weeks' War."

"The following is an extract from a General Order of June 17th, "1866, issued to the Austrian Army just before taking the field:— "'In consequence of a long course of years of peace, the enemy does "'not posses a single General who has had an opportunity of learning "'his duties on the field of battle. Veterans of the Mincio and of "'Palestro, I hope that, with well-tried leaders,' &c. Yet on "July 23rd, within thirty-six days from the date of the above, "when the Austrian Army was utterly prostrate, the following was "the admission:—'Your needle-gun may be a terrible weapon, and "'we know by experience how well it shoots, but it has not been so "'bad for us as your Generals, who have a diabolical power of "'manœuvring.'"

Where, I would ask, was this "diabolical power" attained, if not at the admirably conducted autumn manœuvres of the Prussian Army?

At these campaigns I have now three times been present (and I would say, by the way, have on each occasion been most hospitably received); and it is on them that my present observations will mainly be founded.

I have once visited the French, Austrian, and Russian Armies on similar occasions, but have there witnessed rather a succession of "field days," than, as in Prussia, strategically and tactically speaking, "real, tho' bloodless campaigns," in which, moreover, one's observations and

judgment were materially assisted by an admirably organized system of umpires. One of these umpires is employed at each important point of the field of operations, and their Director-General, if I may so term the officer of rank who superintends the whole, has with him some assistant umpires, one of whom he can detach to observe any contest where some unforeseen cause for arbitration is likely suddenly and unexpectedly to occur.

The umpires are officers of practical field experience, carefully selected from regiments not forming a part of the forces engaged, and capable of impartially deciding what, in each case within their view, would have been the result had actual collision taken place; they are empowered to direct any one brigade, regiment, or squadron to retreat —to retire from action for a given time, and to a given distance, as if to rally,—or altogether to leave the field, according as defeat may be, in their opinion, partial or complete.

The umpires-in-chief have an influential voice in settling, after the daily manœuvres, what positions each army, with reference to the operations of the day, may fairly be permitted to occupy for the night.

They have, during the morning, carefully to watch the action of the whole of the forces engaged, deciding, if doubtful, when the general retreat of either force to a new position, would, in war, have become essential to its ultimate safety; when, for instance, its communications have become seriously threatened; when one or both flanks are fairly and unquestionably turned, or its flank and rear advantageously attacked by the enemy without his compromising his own communications, &c. These questions require considerable practical knowledge and experience for their fair and speedy settlement, and become constant subjects of arbitration in an army whose rule is invariably to combine flank with front attack, practising the system on every occasion, whether it be at the largest of manœuvres, or at the smallest and most common-place of field days, sometimes even when it may be hardly prudent or justifiable.

I had a special opportunity of observing this invariable system of flank attack from having been fortunately induced by Major-general Dalrymple White to go to Berlin ten days or a fortnight previous to the commencement of the greater manœuvres to which we English officers were so cordially invited. This gave us the advantage of seeing a succession of large field days on spacious ground, in which all the principles of modern Prussian cavalry manœuvre, by thirty-eight squadrons, with three batteries of artillery, were more clearly exhibited than could possibly be the case even in a peace campaign. I cannot, perhaps, do better than read to you part of a letter I wrote, on the spur of the moment, to a friend in England:—

"In our very enclosed country, with an extremely jealous agricul-
"tural population, and ridiculously small parade grounds, our ideas of
"manœuvre become as confined as our space, and many consider it the
"chief proof of military ability to be able to handle the largest possible
"force in the smallest possible space: totally ignoring my favourite
"truism, 'ground means tactics,' they will 'box the compass,' at every
"field day; hence the non-pivot system, which, supposing an enemy

" could arise, as at the wave of a wand, simultaneously at every point, " would no doubt be extremely desirable.

" But here the main consideration, and particularly with cavalry, is " to occupy as much ground as can possibly be occupied by any given " force with safety and effect.

" With this object, all supports are in echelon, and often at a slight " angle to the first line, so as partially to be on the flank of a suc- " cessful enemy.

" It is a rule, in every attack to the front by a brigade or regiment, " that the enemy should be charged on one or both flanks nearly at " the same time.

" Thus, an officer commanding a regiment or squadron, who finds " himself in a position to do this, would be expected to do so on his " own authority and responsibility; but in general, an officer com- " manding a division or brigade so forms his force that a front as well " as a flank attack can be made together.

" Their advances in line, which are the chief object of all cavalry " manœuvre, are good, from the officers leading so well both as to " direction and pace; and when they terminate with a charge, it is short, " sharp, and effective.

" A frequent formation for manœuvres, is squadron columns of " pelotons, with full, half, or quarter intervals between the columns, " according to circumstances—an admirable formation for moving over " all sorts of ground, or passing obstacles, and from which a line to " the front or flank is very quickly and simply formed.

" There is only just skirmishing enough done to feel for an enemy, " or to ascertain his line of retreat, and as few men as possible are " employed; but, partly with a view to obtaining intelligence, the " skirmishers are always accompanied by an officer.

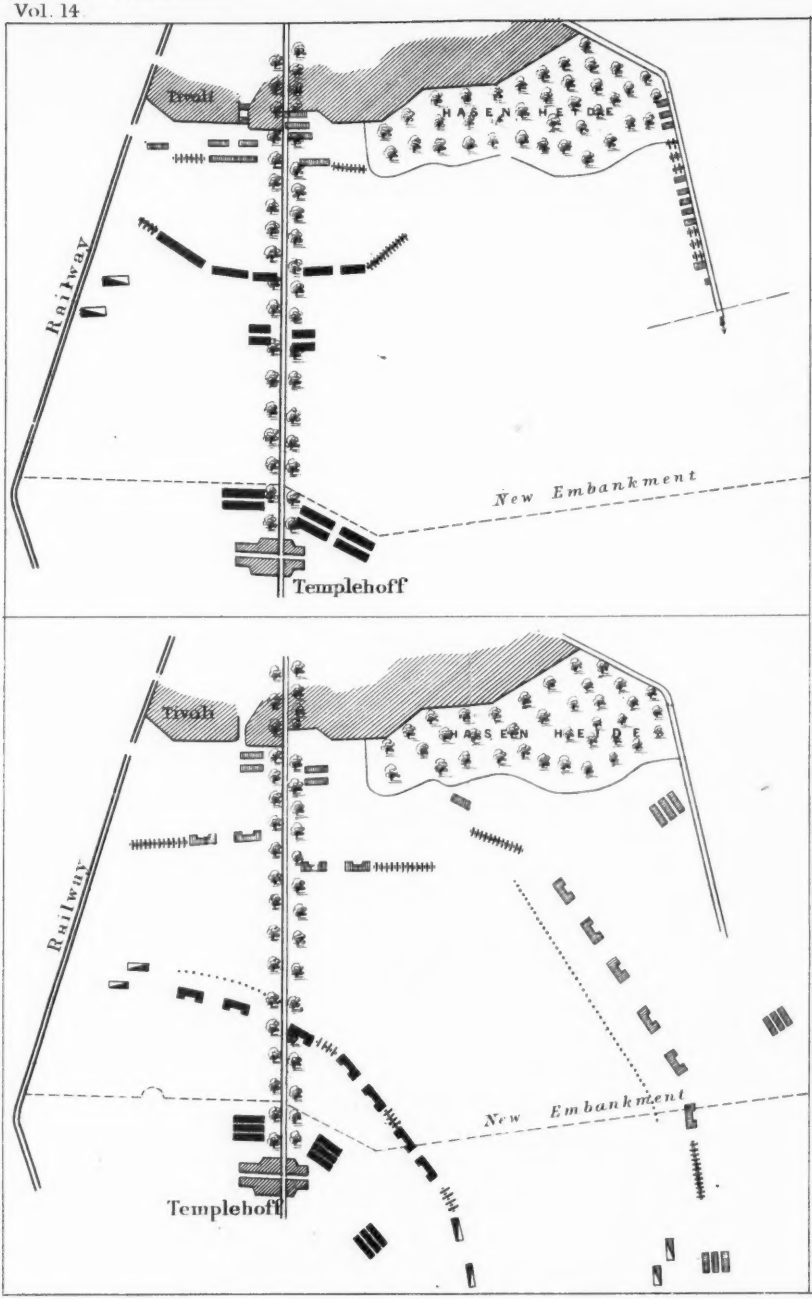
" In all advances over unknown ground, one man a squadron rides " about 250 yards in advance of the line, or line of columns, to ascer- " tain that the ground is safe for cavalry, as well as to watch the enemy. If attacked, they gallop in at once. In the case of a single " column, one or two of these men on *reconnoissance* ride in front, and " two on the pivot flank.

" In most instances, skirmishing in large numbers is simply a waste " of horse power.

" One charge was made to-day in exactly the same formation as " that in which our heavy brigade was attacked at Balaclava. The two " Cuirassier regiments were in line of contiguous quarter columns in " the centre, with a Dragoon regiment deployed on either flank in a line " with the serifile rank of the rear squadrons of the columns, so that " they would take in flank any cavalry attacking the flanks of the " columns.

" Though the centre of this formation would be very vulnerable to " artillery, it is thought by some that against cavalry alone, on con- " fined ground, it would be irresistible.

" The artillery is invariably so placed as to bring an oblique fire on " the enemy, and so that this fire can be kept up until actual contact " between the two lines takes place.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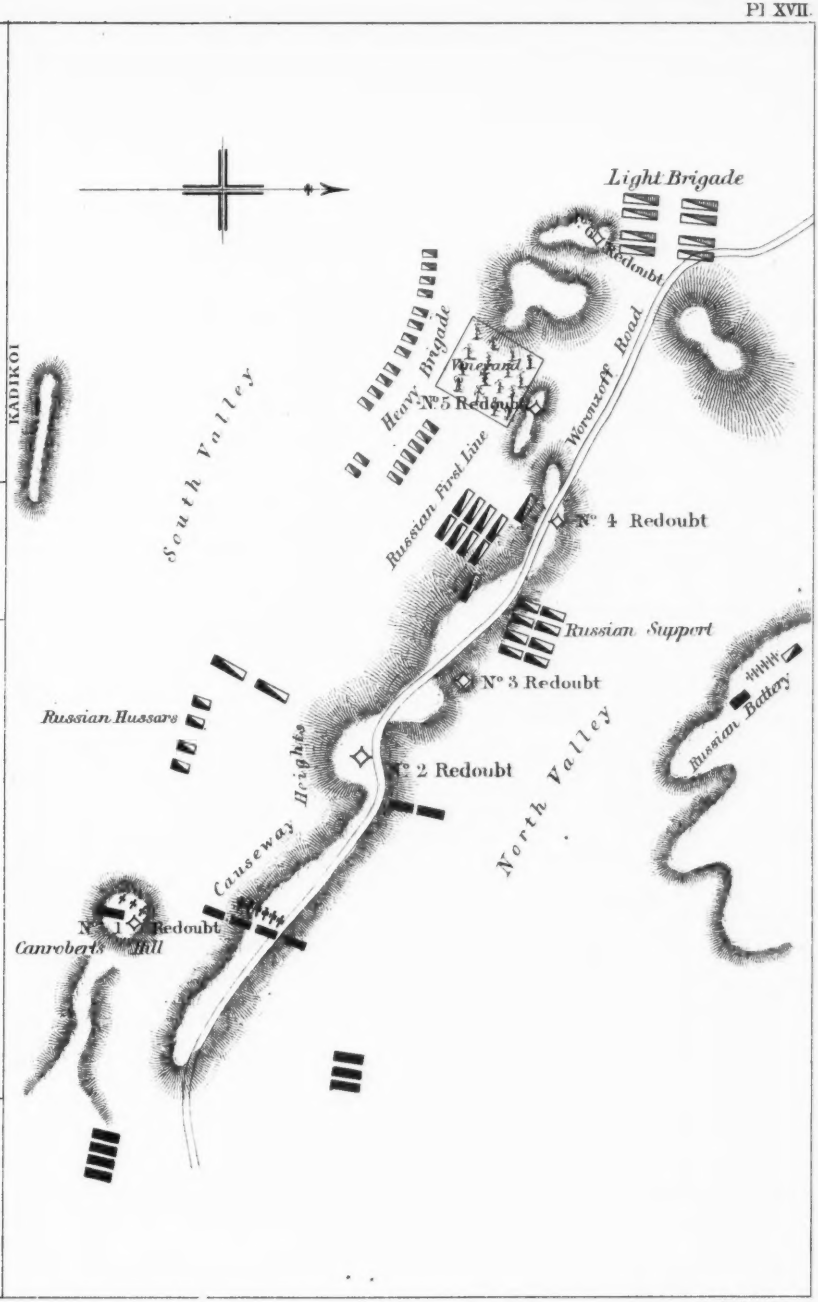
Light Brigade
Redoubt
Heavy Brigade
Vineyard
N°5 Redoubt
Woronzoff Road
KADIKOI
South Valley
Russian First Line
N° 4 Redoubt
Russian Support
N° 3 Redoubt
Russian Hussars
Russian Battery
Causeway Heights
N° 2 Redoubt
North Valley
N° 1 Redoubt
Canrobert's Hill

J Jobbins

"Artillery once occupying a good position remain there as long as "possible, as it is argued that, with the present arms of precision and "long range, when once the exact range is obtained, it is better to "keep it, instead of galloping about from position to position, as "was necessary with smooth-bores. In pursuit, however, the "batteries are pushed on as far and as fast as possible. On "other occasions, the guns are kept rather to the rear, and only "furnished with escort when above 500 yards from the general line of "cavalry."

I have here well-written descriptions of each of the field days to which this letter refers, with an eye sketch of the ground by Mr. Russell, A.D.C. to Major-general White. The field days were conducted against an imaginary enemy; and I looked forward with the greatest interest to the larger manœuvres to ascertain how the perpetual system of flank attack which we had witnessed could be carried out against an enemy equally given to the same system, and who, with well placed echelon supports and reserves, should be able to take in flank those who were so attacking a first line; for flank attack is best met by counter-attack.

These cavalry field days were followed by one of much greater interest, in which the whole Guards Corps, consisting of 38 squadrons of cavalry, 27 battalions of infantry, 6 horse and 10 foot batteries were engaged; here, again, the advantages of well-arranged flank attack were admirably exemplified.

The previous days had, as I have said, been so arranged, as to demonstrate *a perpetual* system of flank attack, while this last showed *one great flank movement* applicable to a general action.

The idea was, that Berlin was threatened by an enemy occupying the village of Templehof, with a line of unfinished railway embankment in front of it, crossing the great main road between the two places at right angles.

The forces were unequally divided, particularly in cavalry, that occupying Templehof being the weaker, and this latter it was decided to attack.

The Berlin force advanced with this view by the road above mentioned, which was flanked by the usual poplar trees; and as soon as the head of the column was clear of the outskirts of Berlin, the advanced guard, composed of two battalions, a squadron of cavalry, and some guns, deployed to the right of the road, and pushed on about half-way across the plain between Tivoli and Templehof, the squadron of cavalry trotting on to reconnoitre the village.

The main body deployed about 800 yards behind the advanced force, having its right protected by a railway, and its left by the wood of Hassen Heide (*vide Plate*).

After some fighting, the enemy drove in the advance of the Berlin force, which retired skirmishing, on the main body. Encouraged by this success, the enemy strongly reinforced his advanced troops, and made a very determined attack on the Berlin army, which had however detached a strong force (including nearly all the cavalry and horse artillery) by a road which, about half-a-mile to the rear, branched

off to the left, and issued into the plain about a mile and a-half to the left front of the position, and where the action was now fiercely raging. A very long, and very gradual, indeed almost imperceptible roll of the ground was just sufficient to hide this force until it was deployed into lines of battle, and had advanced; the enemy then found that the line of embankment and village of Templehof were turned by a strong force that had in no way compromised its own communications with Berlin, and he was thus obliged to bring all his reserves into action to the right, whilst the Berlin cavalry and horse artillery had already extended so much to the left as almost to command the main line of retreat from Templehof.

It will be observed that this was a perfectly safe flank movement, for that portion of the Berlin army first engaged was so strongly posted that it could have held out for some hours against double its strength; both its flanks were well protected, the ground intervening between it and the point where the flanking force issued into the plain was unapproachable, and the preparations for the flank movement were thoroughly screened from view, though an active cavalry should have discovered it before it was deployed and prepared to advance; in this description of force, however, the enemy was weak, and found employment for its squadrons on the other flank, and in reserve. The admirable marching, great endurance, and perfect steadiness of the energetic-looking young infantry, all between the ages of twenty and twenty-five, were very striking. I did not observe the slightest sign of fatigue after long hours of manœuvre in mid-day heat. There was no falling out for a drink of water, as each man of course had, as every soldier should have, his water bottle at his side; this, since Major Cochrane's serviceable invention, will I trust no longer be withheld from our men of all arms.

The quickness with which the officers selected the most trifling inequality of ground to hide and protect, wholly or partially, the troops under their command, on a plateau which at first sight appeared a dead flat, was most remarkable.

In a very open bare country, since the introduction of breech-loading arms of precision with long range, it has become a first necessity, particularly for artillery, to select each of its positions, with some reverse slope, however slight; quickness of eye in this respect cannot be attained without frequent practice, but it is only by such means that the demoralizing "spade" can in a degree be dispensed with.

The difficulties of front attack have become very formidable, modern armaments having so increased the power of defence, that it is doubtful if the finest infantry in the world could drive an enemy from a good position covered by walls, banks, ditches, &c. (unless such shelter could first be nearly destroyed by heavy artillery fire), excepting by turning his flank; and—unless the attacking force be very superior in numbers, and have its centre strongly posted, as a check to counter-attack—it is necessary to success that the concentration and preparatory movements for the flank march should be screened from view, and that the troops should have good marching powers, such as the Prussian infantry, unquestionably, in a high degree possess.

I have troubled you with a detailed account, somewhat tiresome, I fear, of a mere ordinary Prussian field-day, because it so successfully illustrated maxims which were further exemplified on a much larger scale, and under many of the difficulties of actual warfare, in one of those practice campaigns in which the Prussian army and its establishments obtain nearly all the experiences of field service, as to supplies, carriage, field telegraphs, bivouac, out-post duty in every variety of country, patrolling both for safety and for intelligence, reconnoissance (in force, or otherwise as the case may require), passage of rivers, streams, marshes, &c., and the defence, occupation, and attack of woods, temporary field-works, &c., &c.

No private property or crops are allowed to interfere with the proper occupation of a position, or the movements of troops, damages being afterwards fairly assessed: though in villages, farms, &c., the men stand against the outer walls of the houses, which cannot of course be occupied or loopholed for defence; nor can roads, railways, and bridges be destroyed.

Most valuable as these manœuvres are to every one engaged in them, from the General to the private, they are hardly less instructive to the looker-on; for I think that a fair practical soldier, well mounted, and map in hand, may on many points form as just conclusions whilst watching these manœuvres as from actual warfare, particularly when it is remembered how little an officer can see in action beyond his own division or brigade, and the difficulty experienced by military writers in obtaining correct accounts of the commonest details of an action. How many faulty maxims and conclusions are often deduced from utterly false premises, for example, the "thin red line" at Balaclava, and many other instances within our personal knowledge.

Having thus far shown how much the system of flank attack is inculcated, and how it is advantageously carried out on the minor occasions of little more than ordinary field-days, I will now quote from the Prussian practice campaign of last autumn, and from actual wars, two or three instances of failure as well as success (time will not admit of more); for though the flank attack opposed to an enemy wanting in confidence and dash will rarely fail, and throwing troops on to the enemy's line of communication renders close pursuit, easy, and converts defeat into utter rout, still there are certain conditions which may lead not only to failure, but to a serious reverse.

I will avoid any detailed accounts of the manœuvres of the Crown Prince's corps of the Prussian Army in Pomerania, as the admirable letters sent to the *Times* by two most able military writers can hardly be forgotten. I will, therefore, merely remind you, that that corps was divided into two forces, the one under Lieutenant-General Hahen, called the "Army of the North," supposed to have landed on the coast of Pomerania, and blockading the neighbouring fortresses and occupying Stargard; the other, commanded by Lieutenant-General Von Werder, and called the "Army of the South," which had advanced from Berlin to the Ihna to oppose him.

The first and last days of these manœuvres are the two which I should quote as showing that, with forces nearly equal, the detaching

largely to make a wide flank movement is attended with much danger, unless the centre and other flank are very strongly posted, and the design can be hidden from the enemy.

On the first day, the Southern General, intent on turning General Hahn's left flank, with a view to cutting him off from his communications with the coast, extended his force so much that he was ultimately, in the opinion of the umpires, out-numbered at almost every point of attack.

On the last day, the Northern army had retired behind Pansin, and its position extended across the main road leading back to the coast, and communicating with Stargard, whose garrison it was about to withdraw. Its front was covered by a long, wide, deep, boggy ravine, running for some miles to the right, and it could not be turned in that direction. The most feasible passage was in the left centre of the position, but this was thoroughly commanded by a long high hill, which, in fact, was the key of the position, though it was from the first evident that if the enemy could secure some heights on the left rear, at about a mile distant, this important part of the position would be untenable. To effect this, however, after the attack once commenced, the southern Army must detach largely to its right, marching its columns within view, by narrow roads through some dense woods.

The Southern army having made a strong feint against the Northern right, now made three determined attacks on the hill above mentioned; as this, however, was defended by shelter trenches, and two improvised redoubts, the assaults utterly failed; but just before withdrawing from the last attack, we could plainly see some of his troops massing on his right, with the evident object of making a flank movement in that direction, and shortly after saw a large portion of his force moving in columns into the woods; and it was when his centre was thus weakened, that a bold counter attack by the Northern army might have won the day. Instead of this, however, the Northern general prepared to meet the flank attack, and was ultimately considered to have been defeated.

Most flank movements are best met by counter-attack, though there is little risk in attempting a turning movement, when the attacking force is considerably the stronger, and when its centre is securely posted. But it is always an object that the concentration and movement of troops for the purpose should be hidden from view by a reverse slope, or be masked by some obstacles.

Blucher's position at Ligny was faulty, from his reserves being visible to the enemy. Napoleon was thus able to discover his gradual withdrawal of troops towards his right, with the intention of attacking the left flank of the French; and availing himself of the undulating ground occupied by his troops, he moved his powerful reserve unobserved towards the lower extremity of the village of Ligny, and when the Prussians were fully compromised by the flank movement, vigorously attacked their weakened centre with eight battalions of the Guard, and their artillery, and eight regiments of Cuirassiers, which at once decided the day.

At Langensalza, General Flies having first made a feint with a small column against the Hanoverian right, then endeavoured to turn their

left, and thus to threaten their line of retreat,* but in this way so weakened his general line, that the Hanoverians, seizing the opportunity, attacked his centre and defeated him; but pursuit was much checked by the river Unstrut, in front of the Hanoverian position, being only passable at three bridges, one at Thäuesbrüch, on their right, another at Merxlchen in the centre, and a third at Nägelstardt on their left.

Any one, however, who has read with care the accounts of the late campaign in Bohemia, will have observed how invariably the Prussians there carried out with success, on every minor as well as on every great occasion, the principal of flank attack, so much inculcated at their autumn manœuvres.

General von Moltke, sitting in the War Office at Berlin, with two telegraphic wires at his command, was able, so to direct from day to day and hour to hour, the movements of his widely separated armies as not only to prevent their being beaten in detail, but to convert what would, without such means, have been a strategical weakness into the great tactical advantage of throwing the second army on the right flank of the Austrians at the moment when the first army, which had attacked injudiciously early, was actually making cavalry preparations to cover its retreat. Though I admit that, after a careful inspection of the ground, I cannot conceive anything more discreditable to the Austrian cavalry than the surprise of the key of their position at Chlum, added to which, a very few thousand men could have with ease seriously delayed the second army, both in its passage of the Elbe, and its advance in sundry columns by the narrow, steep roads leading up the high, thickly-wooded bank of the valley of the Elbe, towards the plateau of Daubrowitz, rendered deep and muddy from recent rain. Last, though not least, I must mention Blumenau, the final action in the campaign, and in the midst of which, in consequence of the armistice, "The whole, halt" was sounded. Here the forces were about equal, and great was the surprise of the Austrians when, after the termination of hostilities, they found that Prussian troops had not only turned their right flank, but were actually drawn up across the only line of retreat for their artillery; they then honestly acknowledged that they had been saved from a great disaster. It was on this occasion that Hozier tells us that an Austrian officer of distinction said to a Prussian the memorable words with which I commenced this lecture:—"Your needle-gun may be a terrible weapon, but it has "not been so bad for us as your Generals, who have a most diabolical "power of manœuvring."

I will now remark on the three arms in succession, adding a few notes on shelter-trenches, field telegraphs, and the practical instruction of officers of all ranks.

* General Flies' force consisted of about 12,300 men, but having detached five Landwehr battalions for this flank movement, his centre and reserve were reduced to about 8,000. This is taken from a French account, and from "Hozier." This battle also instanced the distinctive effects of breech-loading rifles on the men and horses of artillery, in action, within their range.

Infantry.

Notwithstanding the prejudices of the older infantry officers of other nations, and their arguments as to the great waste of ammunition that would occur, the impossibility of renewing the supply in action, &c., &c., the truly military Government of Prussia had, so far back as 1841, the boldness and foresight to adopt breech-loading arms, and thus became twenty-five years in advance of every army in Europe. The alarm created by her successes in Bohemia at once led to breech-loading arms being everywhere hastily adopted; but though the far-famed needle-gun has been fairly distanced, whether as regards weight, range, or penetration, the Prussians have the advantage of a quarter of a century's experience in its use. They had adopted means of getting up a ready supply of ammunition when required, and drill restrictions to check its expenditure, excepting on those very important occasions when, on its free and liberal use, the fortune of the moment might depend. Their arrangements on these important points have been the result of not merely home practice and manœuvre, but of the two minor campaigns in Baden in 1849, and Schleswig-Holstein in 1863, and lastly, in those crowning victories of 1866, which have made their country the first military nation, and the most powerful empire, in Europe.

Yet, though the first to adopt the new armament, the Prussians have, in consequence, made fewer radical changes in their infantry tactics than either the Russians, the Austrians, or the French; the two last appear to have pushed to an extreme the principle of thin and extended lines, with no compactness and little order.

The longer service, so firmly insisted on by that noble old soldier, their much-loved King, has so improved the physique of the infantry since I saw them in 1846, that they have been able to attain one great necessity of modern warfare, viz., untiring celerity of movement; and this without sacrificing their old solidity.

They have only slightly modified their former depth of formation by the partial deployment of their columns for attack and in line of battle.

The lines of skirmishers can, however, with the needle-gun, deliver a most formidable fire, whilst constantly availing themselves of protection during their quick and determined advance; and can thus most effectually cover their columns and reserves almost up to the point of attack.

Of the skirmishing battalions, usually one-third only of each of the four companies is extended, the other two-thirds being in a column of pelotons in rear of them, which column avails itself of every accident of ground for protection and concealment; this is a simple and effective mode of extension, and is comparatively safe against cavalry attack.

The second line usually follows also in four company columns of sub-divisions, with full, half, or quarter intervals between the columns, according to circumstances, and frequently, in the former case, with the two centre or two flank companies deployed, the battalion being thus formed ready for immediate attack or defence.

This mode of advance is undoubtedly extremely mobile, and has the convenience of passing obstacles, &c., with unbroken facility.

These small columns are also able to take every advantage of undulations, and other protecting features of ground, and in a quick advance it is not easy for artillery to get their range.

To control the expenditure of ammunition, independent firing is almost limited to skirmishers and men under cover.

The Prussian battalions never have their colours renewed; old regiments are proud of having little left of them but ribbons on which their battles are embroidered. The advantages of this are, that they are light to carry, difficult to see at a distance, and thus form no guide to an enemy to judge of the number of battalions in a column or position, and are not a very prominent mark to draw a concentrated fire in action on Officers and non-commissioned Officers in charge of them. In truth the colours are no more necessary to a line regiment than to the Rifle Brigade, and one or both should be dispensed with.

The mode of expansion for war is to increase each company up to 250 men, and battalions move much in company columns of pelotons with deploying, half, or quarter intervals, as before described. The captains are allowed horses, and being thus less subjected to fatigue, are better able to look after their men; the horses are usually held by an orderly some little distance to the rear when the battalion is in action, or the ground is only suited to men on foot.

Varying the number of companies in a battalion in peace and war is an inconvenience, because of the sudden increase and decrease of officers.

Eight would probably be the best fixed number of companies—there are four in Prussia—as there would be two efficient wings of four companies each; for a similar reason cavalry regiments should always have four squadrons each in the field.

Major-General Carey, correctly, I think, attributes the wonderful marching of the Prussian infantry, heavily laden, under a burning sun, over all kinds of ground, to the constant use of their knapsacks. A soldier cannot be too frequently in marching order.

The pouch is carried in front—a decided advantage in doubling, and in other respects; the spare ammunition is carried in the pocket at the base of the knapsack; the bayonet is permanently fixed; a short sword is carried, which adds to weight, without any great advantage.

The men carry about 70 lb. each, and during the manœuvres in Pomerania, must frequently have marched thirty miles a day, on sandy and fallow ground, under a hotter sun than we ever know at Aldershot; yet the constant remark I heard from English officers was, "Very odd, I never see a man fall out."

The Prussian infantry waste no time in practising parade movements. Though they pass their King with a sort of parade step, quick, and with a much bent knee, there are no foolish alterations in the positions of officers, non-commissioned officers, or ranks. The first and second in command only salute, the former turning round to the flagstaff, and the latter succeeding him in charge of the battalion. Drums of the leading regiment remain behind beating time, which the

Infantry.

Notwithstanding the prejudices of the older infantry officers of other nations, and their arguments as to the great waste of ammunition that would occur, the impossibility of renewing the supply in action, &c., &c., the truly military Government of Prussia had, so far back as 1841, the boldness and foresight to adopt breech-loading arms, and thus became twenty-five years in advance of every army in Europe. The alarm created by her successes in Bohemia at once led to breech-loading arms being everywhere hastily adopted; but though the far-famed needle-gun has been fairly distanced, whether as regards weight, range, or penetration, the Prussians have the advantage of a quarter of a century's experience in its use. They had adopted means of getting up a ready supply of ammunition when required, and drill restrictions to check its expenditure, excepting on those very important occasions when, on its free and liberal use, the fortune of the moment might depend. Their arrangements on these important points have been the result of not merely home practice and manœuvre, but of the two minor campaigns in Baden in 1849, and Schleswig-Holstein in 1863, and lastly, in those crowning victories of 1866, which have made their country the first military nation, and the most powerful empire, in Europe.

Yet, though the first to adopt the new armament, the Prussians have, in consequence, made fewer radical changes in their infantry tactics than either the Russians, the Austrians, or the French; the two last appear to have pushed to an extreme the principle of thin and extended lines, with no compactness and little order.

The longer service, so firmly insisted on by that noble old soldier, their much-loved King, has so improved the physique of the infantry since I saw them in 1846, that they have been able to attain one great necessity of modern warfare, viz., untiring celerity of movement; and this without sacrificing their old solidity.

They have only slightly modified their former depth of formation by the partial deployment of their columns for attack and in line of battle.

The lines of skirmishers can, however, with the needle-gun, deliver a most formidable fire, whilst constantly availing themselves of protection during their quick and determined advance; and can thus most effectually cover their columns and reserves almost up to the point of attack.

Of the skirmishing battalions, usually one-third only of each of the four companies is extended, the other two-thirds being in a column of pelotons in rear of them, which column avails itself of every accident of ground for protection and concealment; this is a simple and effective mode of extension, and is comparatively safe against cavalry attack.

The second line usually follows also in four company columns of sub-divisions, with full, half, or quarter intervals between the columns, according to circumstances, and frequently, in the former case, with the two centre or two flank companies deployed, the battalion being thus formed ready for immediate attack or defence.

This mode of advance is undoubtedly extremely mobile, and has the convenience of passing obstacles, &c., with unbroken facility.

These small columns are also able to take every advantage of undulations, and other protecting features of ground, and in a quick advance it is not easy for artillery to get their range.

To control the expenditure of ammunition, independent firing is almost limited to skirmishers and men under cover.

The Prussian battalions never have their colours renewed; old regiments are proud of having little left of them but ribbons on which their battles are embroidered. The advantages of this are, that they are light to carry, difficult to see at a distance, and thus form no guide to an enemy to judge of the number of battalions in a column or position, and are not a very prominent mark to draw a concentrated fire in action on Officers and non-commissioned Officers in charge of them. In truth the colours are no more necessary to a line regiment than to the Rifle Brigade, and one or both should be dispensed with.

The mode of expansion for war is to increase each company up to 250 men, and battalions move much in company columns of pelotons with deploying, half, or quarter intervals, as before described. The captains are allowed horses, and being thus less subjected to fatigue, are better able to look after their men; the horses are usually held by an orderly some little distance to the rear when the battalion is in action, or the ground is only suited to men on foot.

Varying the number of companies in a battalion in peace and war is an inconvenience, because of the sudden increase and decrease of officers.

Eight would probably be the best fixed number of companies—there are four in Prussia—as there would be two efficient wings of four companies each; for a similar reason cavalry regiments should always have four squadrons each in the field.

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band of the next regiment takes up, and so on in succession; thus, exactly the same time is maintained to the end of the longest column.

Men from 20 to 25 are little troubled with long beards, and short service in England will also dispose of that question, as well as of matrimony and pensions.

The staff of a general officer ride behind, and not in front of him.

The cavalry and artillery march past in the same simple, soldier-like way.

The English formal parade movements, general guard mounting, and trooping the colours, which take a vast amount of labour to teach to perfection, might well have gone out with powder and pigtails.

Prussian infantry officers, on all occasions of parade, wear small, light, black knapsacks, which are neat, and a great essential.

Their dress is simple and soldier-like, free from all the vulgarity of tawdry gold lace; the distinctions of rank are so marked that even the youngest sentry cannot mistake them.

The sash (not that of a General Officer!!!) worn over the shoulder instead of round the waist, marks the combatant staff of the Army without the expensive necessity of a fancy tunic, not procurable on service.

They have light "small swords" with sharp, straight cut-and-thrust blades, not attached to long slings to dangle between the legs, but close fitting and with leather, and not steel scabbards to spoil the edge.

Artillery.

The Prussians have retained a considerable number of smooth-bore guns:* whether intentionally, or because they have not yet had the time or means to generally adopt rifle guns, is a question.

The very long range, penetration, and the extreme accuracy of fire, of rifled artillery, when directed against any special single objects, such as buildings, houses, churches, temporary earth-works, &c., is, of course, of the greatest advantage; particularly as, when there is no natural or artificial cover from small arms, it has become necessary that a battery in action should be from 1,000 to 1,200 yards distant from extended infantry; but it must be remembered that every shot that fails to strike its mark is simply lost, and that its moral effects are *nil*.

Nobody who has ever in the course of a slow, chequered, cavalry retreat, sat on a horse perfectly inactive and exposed to even distant fire from round shot,—when, like cricket balls, and nearly as visible, they come bowling along the plain, and, in their flight, either bounding over the ducking heads of his men, or crashing through the ranks, shattering everything they meet,—can for a moment question the moral effects of ricochet fire. The practical effect is still more fatal: for, missing one line or mass of troops, the shot roll into others and penetrate to the tail of a long column instead of proving fatal

* Since writing the above, I have been informed that nearly all the field guns are now rifled, and being breech-loaders, I have avoided reference to shell or shrapnel, in consequence of the "fuze" difficulties, too long on this occasion to discuss.

chiefly to the head, thereby rendering questionable the one great argument in favour of column-formations for attack, viz., that the rear divisions being uninjured, are ever ready to push on the leading files.

But against all this the fatal objection must remain, that smooth-bore guns cannot be efficient from a position beyond the range of modern rifles.

In Pomerania, the artillery was not manœuvred on the same principles as that attached to the Guards Corps near Berlin, but, instead of concentrating the fire in the very open country by a mere alteration in the training of the guns, they seemed to prefer the old system of concentrating batteries, which, with long range, seems a waste of *horse* power and occasions much loss of time. Added to this, it is difficult to find the great length of ridge or undulation required for a commanding and sheltered position for many batteries in line; and in case of advance or retreat, they are too apt, of necessity, to fall into one long column, rendering subsequent formations into line slow, the batteries hampering one another and blocking up a great length of road, the bridges, passes, &c., and impeding other troops or *matériel*.

A battery of artillery is best protected by a strong company or more of infantry, armed with breech-loaders. An instance,—too long now to describe,—occurred on the second day of the Prussian manœuvres, in which the umpire fairly decided that eight squadrons had failed to carry a battery in position so defended. In two or three instances, Austrian guns, with escorts of Lancers, were captured by Prussian cavalry.

The foot batteries come into action with their men neither fatigued nor blown, and are not obliged, in changes of position, to move slowly along at the infantry pace. This is effected by their having five men mounted on each gun, three on the limber and two on seats on the axles, which have a wire screen on the side to protect the men from the wheels, and an iron step for their feet; there are also saddles on the off-horses in case they should be required.

The fore-wheels of the Prussian guns and ammunition-waggons being of different sizes, entails the carriage with each, of two spare wheels, instead of one.

Guns considered as Trophies.

I would here remark that it is very unfortunate that field guns continue to be looked upon as the greatest of trophies; they are in consequence frequently withdrawn prematurely from action, even when their continuance in their position would occasion great losses to an enemy; and what I say, specially applies to artillery covering a retreat. If very full compensation for guns is obtained by the destruction they have occasioned, and by the valuable check they have given to pursuit, their capture is little to be regretted.

Serious loss has frequently been incurred for the sake of guns, with no ulterior or strategical object. As for instance, I may mention at Balaclava, where it was a question of not even field artillery, but merely of six out of nine, iron 12-pounder ship guns, lent by us to the Turks, and

which the Russians were supposed to be withdrawing from the redoubts they had taken. The general commanding the cavalry received an order, "Cavalry to advance rapidly to the front, and try to prevent the enemy from carrying away the guns." Supposing, then, for the mere sake of argument, that it was intended by this order and the other orders connected with it, that the Light Brigade should advance along the crest of the Causeway Heights instead of down the North Valley, and that the Odessa Battalions and other Russian Infantry occupying the redoubts, and in position in rear of them, had been weak enough to retreat before the advancing 600 Light Dragoons, it must be remembered that this line of height was enfiladed by a powerful artillery from the east and flanked from the north by batteries on the Fedukine Hills. The loss incurred for the sake of these six ship guns (not worth the same number of men and horses) must thus necessarily have been great, while success must, in any case, have been doubtful.

Britton, with two guns at Genappe, was another instance of a premature order to retreat, when a round of case, previously to the charge of the 7th Hussars, would have been most effective. It was on this occasion that when gallantly leading a portion of the 7th, Major Hodge was killed, whose son, Major-General Hodge, so long and so efficiently commanded my present regiment.

A first-rate general officer of artillery lately told me, that he considered that an enemy bought a gun dearly, who had first received two rounds of case.

Cavalry.

In Prussia, the cavalry alone is always kept up to the full war establishment, because, as all good soldiers know, it is an arm that cannot be extemporized, and for which it is impossible to have a reserve to fall back on in an emergency. It has been largely increased since the war of 1866.

The cavalry of Prussia consists of Cuirassiers, Lancers, Dragoons, and Hussars.

The first of these is treated entirely as a cavalry of reserve, and not subjected to duties that would be more effectively done by lighter troops, and which, by lightening the condition of their horses, would render them less powerful in a charge. The cuirassiers are fine men mounted on strong, but well-bred horses, and move quickly and well. The Prussians value them as much as ever; indeed they proved their value in Bohemia.

The Lancers are heavy, the Dragoons and Hussars light. The cavalry soldiers, being selected from the riding population, soon learn to be good horsemen, but they have not service enough to be able to turn out themselves or their appointments, or to give their horses proper attention, like our older soldiers; but though our little skeleton regiments are, as regards the individual dragoon and horse, very superior now, yet if augmented suddenly to a war establishment, as was the case before the Crimean war, they would be inferior in every respect to those of Prussia.

The cavalry of an army should not only be as "eyes to its commander," but it should form an "impenetrable screen," behind which all his strategical and tactical combinations can be secretly and safely carried out.

The Prussian cavalry proved of inestimable value in 1866; this was the result of the admirable training gained in all their autumn manœuvres.

The safe issue of two of the Crown Prince's columns from the mountains into Bohemia was secured by his cavalry, particularly at Nachod, where the passage of the fifth corps depended entirely on the 8th Prussian Dragoons and 1st Uhlan Regiment defeating the Austrian cavalry, which threatened the flank of any infantry advancing into the plains of Bohemia. Ultimately, there was a considerable cavalry action.

Cavalry should be fully and well officered, the officers should also be good linguists. A Gazette may make a cornet, but it cannot make a cavalry officer.

No Prussian patrol to the front or flank, ever marches unaccompanied by an Officer of military intelligence, so that no opportunity of reconnaissance may be lost, rendering much dependence on spies unnecessary.

It is said that the Austrians executed 100 men as spies, while the Prussians only employed six, none of whom were captured.

The Prussian cavalry constantly move in squadron columns of pelotons, with full, half, or quarter distance between the columns, according to circumstances. At a distance they appear to be creeping along in a kind of snake-like form, avoiding all obstacles with great facility, and forming line very quickly to front or flank.

A cavalry general should never be with his first line, but always where he can best direct his supports or organize a flank attack. The excitement is such, that it is a great temptation for a good horseman to lead cavalry in a charge.

Lord Uxbridge's gallant and chivalrous nature induced him to gallop into action at Waterloo on the left front of the first line of the Household Cavalry, so that by the gradual inward incline of the Union and Household Brigade he would be in about the centre of the line, but the result was, that being in the *mêlée*, he was unable to check the wild rush of the Greys and Inniskillings and some of the Life Guards and King's Dragoon Guards into the heart of the enemy's position, or to ensure the orders that he had previously most carefully and ably given for support, being effectually carried out.

Cavalry, being in general carried away by excitement, is never so easily beaten as after a successful charge; for practice, therefore, the actual charge, though as rapid as possible, should be very short, a small proportion only being allowed to pursue, supported by the remainder, so as to accustom the men to being thoroughly in hand.

The gallop of manœuvre, and the pace, until breaking into the actual charge, should be fifteen miles an hour, being at the rate of a quarter of a mile a minute.

Great mobility is essential to "arm of opportunity."

In a country favourable to the use of that arm, cavalry must not be much broken up into escorts, divisional cavalry, &c., or it will be beaten in detail; there is generally one portion of a field of action specially suited to its employment, and there it should be in full strength.

An offensive arm, whose sole defence is attack, cannot venture to remain in position, if inferior in numbers to those threatening it, unless, indeed, it is very superior in quality; and cavalry mixed too nearly with infantry, nine times out of ten, in the course of the day, hamper their manœuvres, or mask their fire, and can hardly tend to do more injury in the first instance to a routed foe than can be effected from the long range of the present sniders and armstrongs.

Formerly, the old musket being only effective at about 80 yards, it was an object to have a squadron or two immediately at hand, in order quickly to pursue cavalry recoiling from the fire of infantry squares; but such is no longer the case. Excepting in a peculiarly open country, cavalry piquets and videttes at night are a waste of horse power; they should at dark be withdrawn through a line already taken up by infantry, leaving only a certain number of mounted orderlies. During the day, the infantry required should have rested, cooked their food, &c., on some part of the ground which they would occupy at night, so that the officers should, whilst it was light, have had an opportunity of thoroughly learning the country roads, fences, houses, outbuildings, &c.

A little before daylight, cavalry should again pass to the front, taking a more advanced line of posts, and send patrols to the front and flanks, each of which should be accompanied by an officer of military intelligence, to gain every possible information of the enemy. This system the Prussians advantageously practised in Bohemia.

The flanks of cavalry are so vulnerable, that of four squadrons attacking in line, one squadron should send a troop to be echelloned in rear of each flank, giving flank support independently of the second line.

All cavalry should have helmets sweeping down low behind, in order to protect the back of the neck, and also chains to defend the shoulders.

The employment of cavalry in large masses, under such men as Seidlitz and Zieten, was adopted by the great Frederick, and, after a considerable interval of change, re-adopted by Napoleon; and I believe it to be now more than ever necessary, that this "arm of opportunity" should have its divisions entirely under the control of general officers, who know its rôle, and how to apply it with decision, dash, and celerity.

In France there is a difference of opinion on this subject; but the French have not just now any cavalry generals of special merit or distinction; a strong proportion of cavalry is, however, there still advocated.

A great general of cavalry, the French truly say, is as rare as a great "General-in-Chief;" he must possess a good and quick eye, a cool and determined courage, and great intrepidity, combined with prudence.

Good infantry prepared for attack, with their flanks well covered, should rarely, if ever, be charged by cavalry unsupported by artillery; but favoured by accidents of ground, cavalry should never lose an opportunity of surprise, and by riding at speed, in and over them,

should crush them with that powerful engine, the horse, rather than check the pace for the freer use of their secondary weapon, the sabre.

At Langensalza, the gallant Hanoverian Cavalry did not hesitate to charge the squares of the retreating Prussians, and finally, in a third attack, when a simultaneous charge was made on the other side by the Cambridge dragoons, on a battalion square commanded by a Colonel des Barres, two squadrons of cuirassiers succeeded in penetrating it, and in taking many prisoners.

With the long range and precision of modern guns, pursuit by cavalry, though it should be most energetic, must be conducted with greater prudence than formerly, if the retreat be covered by artillery.

There was no excuse for the French Cavalry not ascertaining the line of the Prussian retreat after Ligny; this ignorance ensured the unopposed concentration of the Allies and the uncalled for division of the French Army, and was one great cause of the ultimate loss of the campaign.

In affairs of cavalry, a general should endeavour to attack the the lighter by the heavier troops; the Prussians carried out this principle with great ability in 1866; though this was rendered comparatively easy by the Austrian so-called Cuirassiers ceasing to be cuirassed, their Lancers having been made light cavalry, and their Hussars being on the smallest cavalry horses in Europe, excepting the little active barbs, now ridden by most of the French light troops.

The squadrons in Prussia are permanently numbered, as are their regiments.

The Russian attack on the English Cavalry at Balaclava, if properly carried out, according to the Prussian system, would have been a good illustration of an engagement between troops of that arm supported by artillery.

Liprandi's object was to attack Balaclava, taking Kadikoi with the camp of the Turks and that of the 93rd Regiment (*vide Plate*). His first operations were necessarily directed against Kamara, and the redoubt on Canrobert's Hill, and those on the line of Causeway Height; these he succeeded in carrying, driving out the Turks, and taking nine iron 12-pounder ship guns. He had next to cross the plain called the South Valley, to attack Kadikoi, and the position occupied by the 93rd Highlanders, covering the gorge leading to Balaclava. But the Division of English Cavalry (about as strong as three good regiments) was in an admirable well-covered position, advancing from which it might at any time threaten his right flank during his movement across the plain, and would threaten his retreat, should he experience a reverse. His first object, then, was to draw this division from the position it was occupying into the plain, and subject it to a flank attack.

With this intent, four squadrons of Hussars were pushed by the opening between the Causeway Heights and Canrobert's Hill into the South Valley, and by manœuvring against Kadikoi, succeeded in drawing from its position one brigade of the English, which, while advancing in column of troops toward Balaclava, had just time to wheel into two lines to its left, to avoid being taken in flank by a very superior force

which suddenly appeared moving down upon it over the Causeway Heights. The four squadrons of Hussars should then have been in a position to have dashed forward against the English right flank.

When that portion of the Russian Cavalry moving over the Causeway Heights, brought its right shoulders up to attack the flank of the English Heavy Brigade, its support should have trotted straight on to check any attempt by the English Light Brigade to attack the flank of the Russian first line (column it was) which, from the position it occupied, it must have done with a broken front, and with a flank exposed to the fire of a Russian battery of Artillery established on the Fedukine Heights (this battery was afterwards forced by an attack of the French Chasseur d'Afrique, to make a short retreat into a new position.) The Light Cavalry not advancing, the Russian support joined in the attack on the Heavy Brigade. (Vide Plate.)

The Prussians consider that a cavalry soldier's proper place is his saddle; and they have as yet done little to utilize their mounted troops as regards dismounted duties; but it should be remembered that the Snider carbines, and, still more, the Martini-Henry, has far greater range and penetration than the Prussian needle-gun, and is much more handy for skirmishing.

Properly trained cavalry should, when on foot, be more than a match for an equal number of infantry, as it can have mounted or dismounted supports as may best suit the occasion, and the men are not encumbered with knapsacks, &c.

Cavalry being thus more independent than formerly of the other arms, may with confidence (without taking into account ground, or other circumstances) threaten the flanks and rear of an army, capturing supplies and destroying railway communications, &c. For the latter purpose a few mounted sappers may be attached with advantage. Such cavalry could also rapidly reach and seize a position, and hold it until the arrival of advancing infantry, or might, on occasions, in extended order, seriously harass a battery which, owing to the configuration of the ground, it might not be able to attack mounted.

The retreat of the last squadrons of Lord Vivian's brigade was effectually protected by some men of the 10th Hussars, whom he had previously ordered to be dismounted and prepared with their carbines to defend the passage of the Genappe. They were placed on a rise on the opposite bank of the river, behind a fence, from which they could command the bridge and the cutting leading to it. The 18th Hussars and the remainder of the 10th supported the dismounted men and protected their horses.

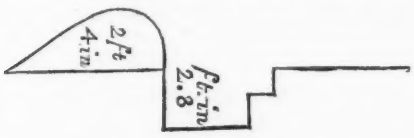
Shelter-Trenches.

During the manœuvres in Pomerania, the only occasion on which "shelter-trenches" were used, was on the last day, by the northern Army, near Pansin, when, as I mentioned in an earlier part of my Lecture, a long high hill, the key of the position, was partially entrenched, obliging the southern Army to make, with part of its force, a very exposed flank movement. In the course of about an hour, as far as I could

ascertain, three two-gun redoubts had been thrown up, and four shelter trenches.

The Infantry were formed in line of quarter columns on the reverse slope of the hill, with about one-fourth of the usual intervals; the intervals were covered as usual with the customary number of skirmishers, which were therefore, in this case, shoulder to shoulder, and hidden and protected in short trenches dug about twenty yards below the crest, on the enemy's side of the hill.

SHELTER TRENCH, AS USED AT THIS MANŒUVRE.



The trenches were of such a depth that men sitting on the reverse step were invisible from the front, and when standing in the ditch the earth thrown up in front was of just such an height as to enable the men to rest their rifles, slightly embedded, on it in their usual firing position, standing.

When the enemy attacked, the skirmishers commenced heavy independent firing, of course to the greatest advantage; and when he, with his columns, advanced well up to the hill, the defending columns having their front quite clear, moved quickly from the reverse slope to the crest of the hill, delivered a four-deep fire, and, charging, drove their opponents in confusion from the position.

I must, however, observe, that neither the French nor Prussian officers generally are favourable to the use of the spade, unless in exceptional cases. They say they do not wish to have their troops turned into armies of Sappers, but that officers must now pay more attention than ever to the accidents of ground for shelter; they consider that the frequent protection of trenches would prove most demoralizing, and that there would be difficulty in getting troops to leave them. There certainly always has been this difficulty as regards buildings that are occupied in the defence of villages, &c.; if they are carried, nearly every defender is in most cases taken prisoner, and thus large numbers are lost to the Army. The Austrian defence of Podoll on the Iser, where the needle gun first proved its deadly powers, was a special instance of this; 500 prisoners were taken.

Great losses in prisoners also occurred in the villages on the Bistritz.

Infantry soldiers, however, have much spare time, and, in addition to trades, cannot be better employed than in practising the use of the spade.

The question of demoralization does not affect artillery, who should be carefully instructed how to throw up earthworks, just enough for

the protection of men and horses, where the conformation of ground will not give it.*

Rifle volunteers, as being more suited to the defence than to the attack of positions, as the American war exemplified, should also be taught an organized system of spade-drill.

Shelter trenches can be made in most ground in from 20 to 25 minutes, sufficient to protect men from fire and view, and yet such that the men can pass over them in line with ease to attack the enemy on his close approach, having been up to that moment protected from his fire. Of every eight men, two should carry spades, two picks, with serviceable axe-backs to them, each weighing about 3 lbs., the other four men could carry cooking utensils, &c. I believe this subject is just now occupying the attention of the military authorities.

Field Telegraphs.

The main object of a field telegraph is to connect an army with the main lines of the country, and so with its capital, or base of operations; and it is in this way that it has been chiefly used by the French in Italy and Algeria, and by the Prussians in Bohemia; and a similar use of it was made by the corps manœuvring last autumn in Pomerania. More than ten miles of wire are rarely required; though I believe a Prussian Army in the field carries with it about 137 miles. Each division has 40 miles.

Each corps of the Prussian Army has with it a complete telegraph-establishment, including materiel of all kinds, carriages, and a boat to lay the wires across the country, rivers, &c.

A person in plain clothes caught in the act of destroying telegraph wires in a campaign, is treated as a spy, and shot.

Practical Instruction of Officers.

Finally, the most important maxim I would draw from the autumn manœuvres of the Foreign Armies, is the positive necessity for officers of practical as well as theoretical knowledge. During European peace, this is only to be attained by superior Officers, by annual practice-campaigns, as in Prussia. The experience which English Officers obtain by wars in India, New Zealand, &c., do comparatively little towards a knowledge of such tactics as must be employed against an enemy thoroughly instructed in the science of war.

Candidates for the Army should be subjected to a practical, as well as to a scholastic test, and the practical and professional preparation could be given by attaching them, probationary, as Cadets to regiments, to be reported on monthly by Commanding Officers.

I have shown in a little pamphlet (lately published by Mitchell & Co. see Appendix) with what facility the last proposal could be carried out, without expense either to the candidate or to the public.

The officers in Prussia are, I may say, elected by their own body;

* The absolute necessity of this, or of keeping artillery in action beyond the range of extended infantry armed with breech-loading rifles, was specially exemplified at Langensalza.

as a commission can only be given by the sanction of the "Corps d'Officiers," they are therefore invariably gentlemen of good reputation socially, and as regards their military acquirements, pull admirably together, are well educated, and are the best practical officers in Europe.

In England, as an economical mode of promoting retirements, a man who never was a soldier may become a lieutenant-colonel, as a colonel when he ceases to be a "soldier," becomes a "general." Relative rank is also at times inconsiderately granted, and thus, when the high grades in our army are so prostituted, and no acknowledged Court precedence given to officers of the Land or Sea Forces, it can hardly surprise one that military rank is much less appreciated than formerly, and that officers take little pride in their profession or their uniform; this in a service adopted in England for honour and glory, and almost without pay, must in the end produce evil results.

The "Bath," too, which from its earliest institution until April, 1847, had been designated The Most Honourable *Military* Order, has, since that date, been largely diluted by the admission of the civil and non-combatant element.

Old soldiers are much better cared for in Prussia than in England, all sorts of government appointments being filled by them. The King sets the bright example of having none but deserving and decorated old soldiers about his person as servants; hence the army is made a proud and desirable employment for good men, and is more looked up to in a social point of view than with us.

I cannot conclude this lecture without expressing the deep gratitude that we English Officers felt for the kindness and liberal,—I should say truly regal hospitality—we received from the Royal Family of Prussia, for the cordial good fellowship accorded us by the Officers of the Prussian Army, and for the ample opportunity given us of obtaining military information from the manœuvres of the most highly instructed troops in the world.

To Baron Korff, to whose care we were specially entrusted, we were likewise greatly indebted, and we shall not readily forget it. Nor can I leave unmentioned the name of our military attaché, Colonel Walker; his information relating to all we were anxious to understand was as valuable as it was always most kindly and readily tendered.

APPENDIX.

Suggestions for the Practical Professional Education of Candidates for the Army, after passing the Scholastic Examinations, at little expense to themselves and at no cost to the Public.

THERE is at present a long list of candidates for the Army, who, owing to recent reductions, will have to wait more than a year before they obtain commissions.

Many of these young men are now idling about London, Brighton, Bath, Cheltenham, &c., at considerable expense to themselves, or to

their relatives, while they would be much better occupied in acquiring the minor details of the profession they hope ultimately to adopt.

This would be effected by their being attached, on probation, as unpaid Cadets, to home regiments of Cavalry and Infantry.

Marks should be allowed for great practical proficiency, according to Commanding Officers' reports; such marks to be added to those obtained at the theoretical examination, and the Cadets to be gazetted to commissions according to the total number of marks obtained.

The scholastic would thus become the preliminary test, and the professional (or practical) the final test of qualification for the Army.

A Cadet when learning the early details of the profession, would be zealously working for the prize, "a commission."

Zeal, the quality in which we now are most deficient, would be a necessary condition of success; and a knowledge of preliminary drills and the routine of regimental duty, would be acquired much more quickly by Cadets who had an object to gain, than by those who had been already gazetted.

By the proposed scheme the country would have a reserve of young Officers more or less formed, from which to augment the subalterns of any regiments suddenly ordered on field service, and would no longer be called upon to issue pay to a proportion of cornets and ensigns as yet unfit to be entrusted with any sort of duty. Regiments, moreover, would be rendered much more efficient than at present, as they would be protected from having young Officers appointed who may be totally unfit for the particular branch of the service in which they have selected to serve.

In the Cavalry, in particular, there is no regiment in which there are not some Officers of whom, within the first fortnight of their joining, the Colonel and Adjutant could not safely predict that they would never make efficient Cavalry Officers. Some of these, it is early evident, can never be made even moderately good horsemen; they have no nerve, take no interest in the management and care of horses, and never ride if they can help it. Some are deficient in sight, some in hearing, some have an impediment of speech, or little or no voice; some are unable to endure any fatigue or exposure, and are given entirely to sedentary occupations; others are so weak as even to be unable to learn the sword or lance exercise, fencing, or single stick. Yet, when once these young men have got their commissions, regiments may be encumbered with them for years. However socially agreeable many of them may be, they are useless as Officers, and a bad example as regards duty. Some of them, from joining too late in life, are positively not only useless, but also unamenable to discipline; but even these cannot be got rid of, unless they commit themselves so seriously as to be liable to trial by court-martial, which at once causes a military scandal.

The Cadet system would not only prevent any young officers who are practically inefficient being appointed to regiments, but would save young men from the very great expense of embarking in the Army without a trial, and fairly ascertaining whether it will be likely to suit them.

Cadets for Cavalry.

1. Those candidates for the Army who, having passed the theoretical examination, have selected Cavalry, should be appointed probationary as Cadets to cavalry regiments quartered in the United Kingdom.

2. Each of these regiments might have a Cadet appointed for every cornetcy that becomes vacant, until the last-ordered reduction is carried out.

Thus, a regiment in which only one supernumerary cornetcy has been absorbed would only have one Cadet, whereas a regiment in which all four supernumerary cornetcies have been absorbed, would have four Cadets, or less, at the discretion of the military authorities, and according to the number of candidates on the list.

3. Cadets should be probationary, and under instruction for about twelve months.

They would be given to understand that they are probationary, and may hope to obtain cornetcies earlier or later according to their merits, as reported on by the Colonels of regiments to which they are attached: or may be rejected as unfit for the particular branch of the service which they have selected, and be sent as probationary Cadets to another; or may be rejected altogether as unfit for the Army.

4. Cadets to be drilled as Cornets now are; to attend stable duties, courts-martial, &c.; to be thoroughly instructed in patrol, escort, and out-post duty, musketry, fencing, broad-sword, lance exercise, and in fact in everything that will try their physical powers.

5. Cadets to have a perfectly plain, inexpensive shell jacket, forage cap, a plain patrol coat (to be worn either alone or over the jacket, according to weather), strong blue cloth trousers, steel spurs, black leather sword belt, white leather sword knot, and cavalry sword.

This uniform never to be worn out of barracks, except on duty.

6. Cadets to have a troop horse to ride only on duty, and never but in the soldier's saddle and horse appointments; to have a bâtman who will look after the troop horse and appointments (which are to be kept in a troop stable), and will wait on the Cadet, clean his clothes, belts, &c., for which he is to be paid 2*s.* 6*d.* a week. With a view to strict economy, no Cadet is to be allowed to keep a horse of his own.

7. A few sealed questions, to be answered in writing, without assistance, in the presence of the Commanding Officer, to be sent from the Council of Military Education to Cadets, monthly or quarterly, on Court-martial duty, Articles of War, Queen's Regulations, and War-office Regulations.

8. Marks should be allowed for great practical proficiency, to be added to those obtained at the theoretical examination; and Cadets should, in ordinary cases, be gazetted according to the total number of marks obtained in the scholastic or preliminary examination, and the practical and final test.

9. Officers commanding regiments who have vacant cornetcies, might apply for the appointment of any Cadets of whom they have received a very high report, with a probability of their appointment, without reference to their position on the list of candidates; the Cadet's

character from the Commanding Officer being sent to the Military Secretary with the application. This would be a great encouragement to Cadets to be well conducted, and to learn their work, as Lieut.-Colonels commanding regiments would, for their own sakes, select the best young officers they could find. This plan is somewhat after the Prussian system of selection from the one year Cadets in the ranks.

10. Lieutenant-Colonels should be held strictly responsible in case, when a cornet joins a regiment, his conduct and practical acquirements are reported not to be equal to their representations in every particular.

11. Commanding Officers of regiments should have the power of placing a Cadet under arrest, but must report the circumstances at once to the Adjutant-General, Horse Guards.

12. The Cadets should be required to live regularly at the mess as honorary members, but only be allowed to pay for the breakfast, lunch, and dinner, of which they partake; they should be forbidden to contribute to mess donations, subscriptions, or extras of any kind; and should not be charged for any public or private guests. The Commanding Officer would be held responsible for these rules being strictly observed. The Cadets to wear the plain shell jacket and blue trousers at dinner.

13. If there be vacant Officers' quarters in the barracks, it would be desirable for the Commanding Officer to apply for leave for his Cadets to occupy them, subject to the usual damages, but the public must not be charged with coals or candles.

In case of there being no spare quarters, Cadets must procure lodgings (which Commanding Officers will take care are in the immediate neighbourhood of the barracks) at their own expense.

14. Colonels commanding cavalry regiments to report on their Cadets monthly, stating in each case whether the Cadet is gentlemanlike in his conduct, good tempered, amenable to discipline, likely to make a good horseman, fond of and anxious to understand the management of horses; whether he has good nerve, quick sight, a good eye to country, and a sufficient knowledge of military drawing to be able to make a simple, rough eye sketch from horseback, and is healthy, active, energetic, and equal to the fatigues of a campaign.

All reports, special or monthly, on Cadets, to be made direct to the Adjutant-General, Horse Guards.

15. Guards and sentries not to pay compliments to Cadets; but Non-Commissioned Officers and soldiers to salute them, and to be liable to punishment for any disrespect.

16. No leave of absence to be given to Cadets excepting to stay with relations; other leave leads to extravagance.

Cadets for Infantry.

The regulations proposed for cavalry Cadets would apply equally to those attached to infantry regiments, excepting as regards horses, riding, and uniform, which latter should be the same as that worn by Sandhurst Cadets.

Infantry Cadets should be encouraged to apply to be for a short time attached to cavalry, as equitation is best acquired in early youth, and it is most desirable that mounted officers in every branch of the Service, should be fair horsemen.

Army in General.

It is notorious that there have been many Officers of high military educational acquirements who have been, from first to last, very indifferent Officers in the field.

If the Lieut.-Colonels commanding regiments were questioned, there is not one in ten that would not agree in the advisability of a practical as well as a strict theoretical test for candidates for commissions.

Officers would virtually join the Army at an earlier age than they do now:—a great advantage, if only because discipline is a habit only to be acquired in youth.

The most efficient Brigade-Majors and Aides-de-Camp, as was amply proved in the Crimea, may be chosen from amongst the best of the regimental Officers; for higher commands, general Officers should be selected from those who have previously commanded regiments and brigades.

England ought to have the best Cavalry and Infantry Officers in the world.

The manly games, knowledge of character, readiness of resource, social pride, and love of truthfulness and honour, inculcated and practised at Winchester, Eton, Harrow, and our other great public schools, added to the love of enterprise, good nerve, and quick eye to country acquired by our national field sports—for ground means tactics—form an admirable preparation for the final practical test proposed.

As things are, we get our best Officers chiefly from a class who, being in a pecuniary sense independent, remain in the Army only from pure zeal and love for the profession; but few of whom, unfortunately, like Indian or colonial service, though they would willingly and cheerfully endure all the hardships of the most severe and lasting campaign.

It is better for the State that Officers of the Army should not be mere military adventurers, but should, at all events by connection, be interested in order, and the security of property; and their being of a class far superior to the soldier in social position, ensures them respect, and renders command comparatively easy and effective.

Practical professional education for the higher ranks of the Army can only be attained by the Prussian system of regular peace campaigns.

Evening Meeting.

Monday, March 21st, 1870.

REAR-ADMIRAL SIR FREDERICK W. E. NICOLSON, BART., C.B., Vice-President, in the Chair.

NAMES OF MEMBERS who joined the Institution between the 14th and 21st March, 1870.

LIFE.

Lloyd, E., Lieut. 108th Regt., 9*l.*

ANNUAL.

Symes, W. A., Capt. 94th Regt. 1*l.*
McCreagh, M., Major, late 4th Dragoon Gds., 1*l.*
Eaton, H. F., Lieut. Gren. Gds. 1*l.*
Sprot, J., Lieut. Col., 91st Highlrs. 1*l.*

THE PROGRESS OF OUR HEAVY ORDNANCE AND THE PRINCIPLES AND PROCESSES OF ITS CONSTRUCTION.*

By Captain F. S. STONEY, R.A., Assistant-Superintendent Royal Gun Factories, Woolwich.

WHEN the Council of the Royal United Service Institution did me the honour of inviting me to read a paper on the construction of heavy ordnance, my first impulse was to refuse, because I knew well the magnitude of the subject, and my own inability to deal with it properly; but on second thoughts, I considered that such conduct would be moral cowardice on my part, as well as ungrateful towards this Institution, the benefits of which I have been silently enjoying for several years back. I consequently consented to read a paper, resolving, however, to confine my observations to our own guns—the Government guns which are actually in our land and sea services—and to avoid as much as possible any invidious mention of foreign ordnance, or of the merits of the various experimental systems, the inventors of which are for the most part both able and willing to advocate their own cause.

Hence it is that I appear before you to read a paper on "The Pro-

* Portions of this paper have appeared in the Royal Artillery Institution Proceedings.—F. S. S.

gress of our Heavy Ordnance, and the Principles and Processes of its Construction." The subject is one of immense Military moment, for of all weapons of war, the big gun is of paramount importance to Great Britain. Continental nations may rely on their infantry breech-loaders, or on their numerous field artillery; but to England,

> Whose march is o'er the mountain waves,
> Whose home is on the deep,

heavy artillery is an absolute necessity of imperial existence; for no one whose mind is not narrowed by regimental prejudices will attempt to deny that our insular country, with its wide spread colonies and extensive commerce would cease to rule the seas if the Union Jack, afloat and ashore, waved over less powerful guns than those of our neighbours. But this point is so obvious to the professional audience which I am addressing that I will not dwell any longer upon it, but pass on at once to my subject, which is really so extensive that the utmost I can hope to do within the prescribed time is to bring the leading features of it to your notice.

What, then, do I mean by the progress of our heavy ordnance? Simply this. The battles of the Nile, Trafalgar, and all the other naval actions about the beginning of this century, were fought and won with no heavier pieces than 68-pounder carronades of 36 cwt., for short ranges, and 32-pounder guns of 56 cwt.; and that if we went to war to-morrow, some of our ships—the "Captain" and "Monarch" to wit—might go into action with 12-inch guns of 25 tons, capable of penetrating any hostile ironclad afloat at short ranges; or, if distant firing were required, capable of throwing their 600 lb. projectile into a moderately sized magazine two miles away.

I will now very rapidly trace this progress of our heavy ordnance. The first marked improvement, after Lord Nelson's time, was made about 1830 by General Millar, R.A., the head of the Gun Factories at Woolwich, who introduced the 8-inch and 10-inch shell guns, for horizontal firing. Ten years afterwards, *i.e.*, in 1840, Mr. Monk, Chief Clerk in the Department, proposed the 42-pounders and 56-pounders; and subsequently to this, Colonel Dundas, R.A., who succeeded General Miller, introduced 68-pounders—a great stride, as it was then thought, in the progress of heavy ordnance, and so indeed it was; but the supremacy of the 68-pounder was not of long duration. It is no longer a heavy or a powerful gun, according to modern artillery ideas. It has been dwarfed by its big rifled brothers of recent date; but the origin and growth of rifled ordnance constitute such an important and novel era in the history of artillery, that I must henceforward proceed with greater deliberation and detail, premising that my facts and figures are principally taken from published official documents.

When the Crimean war was impending, the general adoption of rifled small arms necessitated the introduction of rifled ordnance, in order that artillery might still retain its superiority over infantry, and remain, as before, the principal arm in the field, which certainly would not be the case if an enemy's skirmishers had the power of

placing a battery *hors de combat* before its too-short ranged guns could be brought into action on the advancing columns.

To supply this great want in warfare involved a complete reformation in the architecture of artillery, which had been almost at a standstill since the time of the Tudors; for although modifications had been occasionally made in the manufacture of ordnance, any one who examines the old guns in the Tower of London, or in the Museum of Artillery at Woolwich, may see that they are of the same genus as modern smooth-bores, and even notice some specimens quite as soundly and as artistically cast as any of those of the present century, nay more, he may infer that our modern cast guns can scarcely be superior to their prototypes in range-power, or susceptibility to rifling.

It is, however, worthy of note, that this stagnation in the construction of ordnance was not to be attributed to ignorance of the theories of gunnery, but to the backward state of metallurgy and mechanism, for professional as well as amateur artillerists have, even at remote periods, understood the value of rifled guns, but their endeavours to obtain them were rendered abortive by the want of suitable materials and proper machinery.

Such being the state of the case, it was indeed fortunate for the ascendancy of artillery that, owing doubtless to the spread of railways, suspension bridges, &c., &c., the requisite improvement in metallurgy and in mechanical appliances should have opportunely taken place in recent years. It is only of late that the manufacture of cast-steel as a material for rifled ordnance has made rapid progress, whilst the difficulties which used to attend the forging of wrought-iron in large masses were so great that a heavy anchor was one of the greatest achievements of the forge-master until the comparatively recent introduction of steam-hammers enabled him to forge our modern monster guns. But, thanks to the able mechanicians of the day, we have now rifling machines so perfect and so easily manipulated that the operator could, if he pleased, engrave his name in the bore of a gun, and withal so accurate is their action, that they work "true" to less than $\frac{1}{1000}$th of an inch, a dimension which can now be very easily measured by means of a Whitworth's micrometer, but which is fifty times too minute to be ascertained by the primitive measuring instruments of the last generation of mechanics.

In the lull which succeeded the Crimean campaign, the continental nations turned their attention to the rifled artillery problem. The Emperor Napoleon III was particularly energetic in the matter, and the French rifled field gun contributed nearly as much to the defeat of the Austrians at Solferino, in 1859, as the Prussian needle-gun did to their defeat at Sadowa seven years afterwards.

Meantime, the Indian mutiny did not prevent our own authorities from carrying on careful and comprehensive experiments with breach-loader rifled guns, on Mr. (now Sir William) Armstrong's system, which he brought first to official notice in December, 1854.

At the same time, extensive experiments were carried on to test whether any safe method of strengthening cast-iron guns could be found, or whether any better, speedier, or cheaper system of construct-

ing rifled ordnance existed than that proposed by Sir William Armstrong. None such having been found within the period for inquiry, the Armstrong system was completely adopted;* and in order to obtain a supply of the guns and projectiles as soon as possible, so that we might not be behind other nations, Government not only entered into a contract in January, 1859, with the newly-established Elswick Ordnance Company, but commenced their manufacture in the Royal Arsenal, Woolwich.

Our field artillery was soon furnished with the new field guns, and a goodly number, especially of the larger natures, were, at the urgent request of the Admiralty, supplied to the fleet, and subsequently the whole series of Armstrong guns, from the 6-pounder of 3 cwt. to the 7-inch of 82 cwt., was added to our armaments.

These breech-loaders were used on active service in China, New Zealand, Japan, and Cape Haytien (1866); and although they did not play their part so perfectly well in the heat of action as at their quiet rehearsals at Shoeburyness, their performance, on the whole, was excellent, and fully justified their adoption by the Government. But it is the heavier natures—7-inch and 40-pounders—which most concern now; they were used both at Japan and Cape Haytien, and especially at the latter place, with great success.

Notwithstanding the progressive excellence of his breech-screw guns, Sir William Armstrong introduced not only two natures of wedge-guns (40-pounders and 64-pounders) as an improvement on the breech-screw arrangement, in points of safety and simplicity, but also 64-pounder muzzle-loading guns with shunt rifling, and proposed other shunt guns of larger calibre.

As was natural, however, in this mechanical age and country, Sir William Armstrong was not permitted to bear away the palm without a contest.

Various propositions for rifled guns were submitted to the Ordnance Select Committee, and in 1858 General Peel, the then Secretary of State for War, "called upon Colonel Lefroy, his scientific adviser, for a report on all the experiments that had been tried on rifled ordnance," and in accordance with the recommendation of that report, appointed a Special Committee to examine as to what was the best rifled gun for field service. This Committee came to the conclusion that it was not expedient to incur the expense of trying further experiments with any except those of Messrs. Whitworth and Armstrong.

The trial accordingly took place; but as at that time Mr. (now Sir J.) Whitworth did not propose any gun of his own construction, and had only rifled Government blocks of brass and cast-iron, the Armstrong breech-loading gun, which was complete in every respect, was, as we have seen, adopted. Nothing daunted, however, Mr. Whitworth carried on a series of private experiments, and having perfected his plans, he obtained such good results with his guns that he again challenged the rival system which the Government had adopted.

A Special Committee was then appointed, 1st June, 1863, to examine

* Report of the Select Committee on Ordnance, 1863.

and report upon the different descriptions of guns and ammunition proposed by Sir W. Armstrong and Mr. Whitworth.

The inquiry was to embrace the comparative qualities of the several systems with respect to range, accuracy, endurance, ease of working, cost, &c., the fitness, in short, of the guns and ammunition for the various purposes to which ordnance may be applied either on land or sea service.

The Committee accordingly made patient and extensive competitive experiments with Whitworth 12-pounders and 70-pounders, Armstrong 12-pounder and 70-pounder breech-loaders, and Armstrong 12-pounder and 70-pounder muzzle-loaders; the 12-pounders having been chosen to decide the question for field artillery, whilst the 70-pounders were the best available representatives of heavy artillery, comprising siege, garrison, and broadside guns.

The Whitworth guns were muzzle-loaders, and had his well-known hexagonal rifling, and mechanically fitting projectiles.

The 12-pounders were of solid mild steel (having trunnion rings screwed on to them) with a hoop of the same material over the powder chamber.

The 70-pounders were of the same material, but consisted of an inner tube closed by a breech-screw and strengthened by hoops pressed on cold by hydraulic pressure.

Sir William Armstrong, who declared that his system was not limited to breech-loaders, put forward both breech-loaders and muzzle-loaders for competition; both were constructed with steel barrels, and with wrought-iron coils superimposed as usual.

After a searching examination of important witnesses, and complete and comprehensive trials, which cost over £30,000 for stores &c., and which lasted two years and a half, the Committee concluded their labours.

The results of these experiments were very creditable to both inventors, especially as regarded the construction of their respective guns, each of which, after firing about 3,000 rounds, was only burst at last by abnormal means; but the report was, on the whole, most in favour of the Armstrong muzzle-loaders, and among the points of the utmost importance to gunnery, which the Committee established in the course of their experiments, are the following:—

"That muzzle-loading guns can be loaded and worked with perfect "ease and abundant rapidity.

"That guns fully satisfying all conditions of safety can be made "with steel barrels, strengthened by superimposed hoops of coiled "wrought-iron, and that such guns give premonitory signs of ap-"proaching rupture; whereas guns composed entirely of steel are "liable to burst explosively, without giving the slightest warning to "the gun detachment."

The expensive and extensive experiments of the Armstrong and Whitworth Committee and the conclusions they arrived at in favour of the former system, which has since been brought to such simplicity and perfection in our present service guns, are very interesting and suggestive at the present moment, when a further trial of Sir Joseph

Whitworth's guns is said to be smiled upon by the powers that be. But I have referred to the facts of the case because they bear directly on the construction of our heavy guns, and save me the trouble of discussing the merits of the various materials for ordnance, except to say that all our experience up to the present corroborates the opinion of the Committee that steel from its hard and elastic nature is the best material for the inner barrel, and that coiled wrought iron is the most suitable for the exterior parts, as its pliant and fibrous character checks and counteracts the explosive tendency of the steel.

Necessity for heavy M.L. Rifled Guns.

It is remarkable the effect which rifled guns had on the science of artillery. Although rifled guns were made more powerful than the smooth-bore 68-pounders, they soon became insufficient for the modern requirements of naval warfare, for the power and precision of rifled guns and the growing use of concussion shells which would burst on striking on a ship's side and make a hole beyond repair, or having penetrated, would burst between decks, dealing death and destruction around, and probably setting fire to the vessel, necessitated the use of ironclads. To penetrate these necessitated in turn still more powerful guns, and then commenced the Shoeburyness campaign of guns *versus* armour plates, which is not yet decided.

The judgment which the Armstrong and Whitworth Committee pronounced in favour of muzzle-loading guns was only in accordance—so far at least as heavy guns were concerned—with the preconceived opinion of our leading artillerists, for any breech-loading arrangement with guns using the enormous charges required would not only be too cumbrous but actually unsafe.

As the striking effect of a projectile depends more on its velocity than on its weight, and as a round shot fired from a smooth-bore gun has considerably greater initial velocity than an elongated shot fired from a rifled gun, owing to the friction in the bore of the latter, as well as to its smaller proportionate charge, the Admiralty at first proposed wrought-iron smooth-bore guns of large calibre to penetrate armour-plated vessels at close quarters. Accordingly in 1864, after mature experiments, two natures of wrought-iron smooth-bore guns were adopted; these were the 100-pounder of 9″ calibre, and 150-pounder of 10·5″ calibre. They were built up on the Armstrong coil principle, but only about fifty of the former, and a dozen of the latter were made, as it soon became evident that still more potent guns were necessary, and that we could make them too in the shape of wrought-iron M.L. rifled guns. In fact, such good results were obtained from the 64-pounder M.L. shunt gun (which was approved as a sea service gun March 10, 1865), as well as from larger experimental guns on the same system of rifling and construction, that the O.S. Committee suggested (Report No. 3553, 25/11/64), that the above two natures of smooth-bore guns should be also rifled on the shunt system.

But the shunt-rifling itself was eclipsed in 1865 by the "Woolwich" system, and as the steps which led to this result throw con-

siderable light on the whole system of rifling, they will be briefly referred to.

By instructions first received from Lord Herbert in 1859, the O.S. Committee carried on an extensive trial of cast-iron 32-pounder guns rifled for different gentlemen in accordance with their respective views as to the best way of rifling the existing store of smooth-bore cast-iron guns.

The result of this competition simply proved that cast-iron was altogether too weak and precarious a material for rifled guns.

The trial was then extended to wrought-iron guns rifled on the respective systems of Commander R.A.E. Scott, R.N., Mr. Lancaster, Mr. Jeffery, and Mr. Britten, who with Messrs. Lynal Thomas, Hadden, Nasmyth and Whitworth, were rivals in the cast-iron competition.

A gun rifled with French grooves and another gun with shunt grooves were also tried.

All the guns selected for competition were 7-inch muzzle-loading guns of 7 tons, built on the Armstrong coil principle, and having inner barrels of steel.

Experiments were carried on which tested these competitive guns in all the cardinal virtues of ordnance, and though the shooting qualities were alike, the O.S. Committee in their final report, No. 3730, dated 1st May, 1865, recorded their unanimous opinion in favour of the so-called French system:—

1. "Because of the simplicity of its studding on the projectiles.
2. "The simplicity of the grooving of the gun, and
3. "From a disposition to admit the advantages of an increasing "over a uniform spiral."

And further, the Committee recommended "that the heavy 7-inch "guns then in course of manufacture should be rifled in the same "manner as the competitive so-called French gun, except that the "width and depth of the grooves should be slightly decreased, and "that 8-inch and 9-inch guns also should be completed with similar "rifling." Fig. 1, plate XVIII, shows a section of the modified groove.

The Woolwich Guns.

This was the origin of those powerful pieces of ordnance known by the comprehensive term of "Woolwich guns," a binomial which may be expanded into "wrought-iron muzzle-loading guns built on Sir "William Armstrong's principles improved by Mr. Anderson's method "of 'hooking' the coils, and with solid-ended steel tubes toughened "in oil and rifled on the French system, modified as recommended "by the O.S. Committee for projectiles studded according to Major "Palliser's plan."

It is now time to consider the principles of this construction.

To Sir William Armstrong is undoubtedly due the merit of employing wrought-iron coils shrunk together. His main principles of gun architecture consist essentially—

Firstly, in arranging the fibre of the iron in the several parts of

Fig. 1

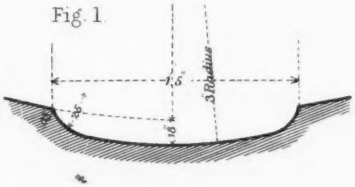


Fig. 2

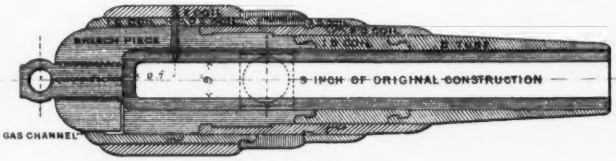


Fig. 3.

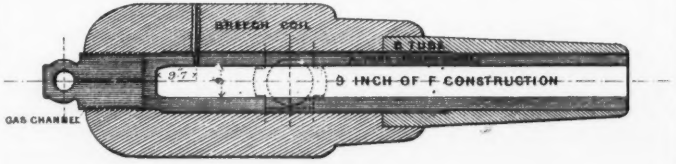
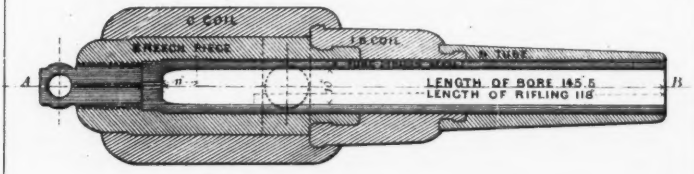


Fig 4.

WROUGHT IRON MUZZLE-LOADING GUN 10 INCH 18 TONS.



J Jobbins

the gun, so as best to resist the strain to which they are respectively exposed; thus the walls or sides of a gun are composed of coils with the fibre running *round* the gun, so as to enable the gun to bear the transverse strain of the discharge without bursting; whilst the breech end is fortified against the longitudinal strain, or tendency to blow the breech off, by a solid forged breech-piece with the fibre running *along* the gun. Secondly. In shrinking the successive parts together, so that not only is cohesion throughout the mass ensured, but the tension may be so regulated that the outer coils shall contribute a fair share to the strength of the gun.

With regard to the first principle, a gun may be destroyed either by the bursting of the barrel, or by the breech being blown off. Now wrought-iron in the direction of its fibre is about twice as strong as it is in the cross direction; hence the best way to employ it to resist the transverse strain is to wrap it round and round the piece like a rope. This is the foundation of the Armstrong coil system. For a similar reason the best way to resist the longitudinal strain is to place the fibre lengthways or end on; so a breech-piece was made from a solid forging with the fibre in the required direction.

With regard to the second principle, the strength of a gun is not proportional to its thickness. The interior of a homogeneous gun bears the brunt of the discharge, while the exterior parts are scarcely affected. The exact law which regulates the amount of resistance offered to the discharge, by each lamina of the gun is not precisely known, but it is admitted that *a gun should, if possible, be so constructed that each part of its mass would do its due proportion of work at the instant of firing.*

Sir Wm. Armstrong endeavours to carry out this theory by giving, through means of shrinking, greater tension to the outer coils than to the inner ones, so that the former do a certain amount of work in compressing and energetically supporting the latter, which are thus strengthened at the expense of their exterior neighbour, and the theory is further carried out by the employment, in addition, of a stronger material (steel) for the inner barrel.

You will observe that although our breech-loaders are commonly called "Armstrong guns," the muzzle-loaders built on the same principles have an equal right to that honourable title; but seeing that there were many modifications made by various people with regard to the rifling, &c., they have been, as already stated, styled "Woolwich guns." And this name should still, I think, be applied to the present guns, for they are a modification of the original ones, and that modification is the fruit of the Royal Gun Factories at Woolwich.

"Woolwich guns" of 7-inch, 8-inch, 9-inch, 12-inch, and 13-inch calibre—very few, however, of the higher natures—were made up to the close of 1866 on the "Armstrong" or "original" single coil system. As a type of the rest, I will briefly describe the construction of the 12-inch gun of 23½ tons.

This gun consists of a solid-ended steel barrel, a forged breech-piece, a trunnion-ring, a cascable, and nine coils—thirteen separate parts.

The steel cylinder having been bored for a barrel and toughened in oil, is turned on the exterior to suit the interior of the breech-piece, which has been built by a series of wrought-iron slabs successively welded together and then drawn out, bored, and turned. The breech-piece will not fit on the steel tube, both being cold, the difference in size being the designed shrinkage. The breech-piece must, therefore, be expanded by heat until it is sufficiently large enough to go over the end of the steel barrel, where it is allowed to cool and contract or shrink.

The screw is then cut for the cascable, and the mass taken to the turnery and turned down for the 1·*B* coil,* which is shrunk on. The mass is then turned down in succession for the 2·*B* tube, which is composed of two coils united together. This is shrunk on, and so on coil by coil, until the whole gun is built or shrunk up. The gun must still be turned on the exterior to its proper shape, rifled, proved, sighted, &c., &c., before fit for issue.

So far as strength and efficiency were concerned, these guns were nearly all that could be desired, but their expense, £100 a ton in round numbers was a serious point, and to diminish it Colonel F. A. Campbell, who succeeded Sir W. Armstrong as superintendent of the Royal Gun Factories in 1863, set practically and patiently to work. Two questions presented themselves for solution.

(1.) Could not a coarser and cheaper iron be obtained which would be sufficiently strong for the exterior of the gun?

(2.) Could not the guns be constructed in a simpler and cheaper form?

By personal visits to most of the leading ironmasters, and by a series of experiments, Colonel Campbell had already found a very superior and satisfactory iron for the inner barrels of B.L. guns, and by following up his success, he now obtained a very cheap iron sufficiently strong for the exterior of our heavy guns, whilst in the plan of construction proposed by Mr. R. S. Fraser, C.E., Royal Gun Factories, he discerned a still more gratifying solution to the second question.

Mr. Fraser's plan is an important modification of the original method, from which it differs principally in building up a gun of a few long double or triple coils instead of several short single ones and a forged breech-piece.

For example, in addition to the steel barrel and cascable, a "Fraser" gun of the pattern most generally followed has only two separate parts, viz., the breech coil and *B* tube (or as they are sometimes familiarly called "the jacket and trowsers") whereas the 9-inch gun of original construction has a forged breech-piece, a *B* tube, a trunnion ring and seven coils—ten distinct parts—which are shrunk on separately. (See Figs. 2 and 3, plate XVIII.)

The formation of a double or triple coil is a simple forge operation, but great expense is saved by its means, as there is so much less surface to be bored and turned, for each coil having to be made as smooth as glass and at the same time true to gauge (to a thousandth of an

* The various coils are lettered as a ready mode of description.

inch) it follows that it must be cheaper to have a few thick ones in lieu of many thin ones. For the same reason there is also less waste of material, for although the turnings are afterwards worked up into bars, iron in its scrap state is only worth one-third of its forged value.

Moreover, time and labour are also saved in having fewer pieces to move from workshop to workshop; for instance, in the case of a gun of original construction, when a coil was shrunk on, the mass had to be moved from the shrinking pit to the turning lathe, and turned down for the next coil, and so on, coil by coil, until the gun was built; but in the new construction, only two or three separate shrinkings are required; and it is computed that where 50 tons were moved in the former case, only seven are moved in the latter.

From these circumstances, combined with the employment of cheaper iron, a "Fraser" gun can be made at two-thirds of the cost of a gun of the same nature as originally manufactured.

But it will be naturally asked, is this cheap construction as strong as the old one?

With respect to theory it may be urged in its favour, in the first place, that a forged breech-piece (which is a comparatively expensive article, and liable moreover to fly into fragments should the gun burst) is not required with a solid-ended steel barrel and long thick coils, although it is absolutely necessary with several short coils to compensate for the longitudinal weakness of their several joints. The whole of the wrought iron therefore can be *coiled* round the barrel and thus give extra transverse strength. Again, the trunnion ring, which was merely shrunk on in the original construction, is *welded* on to the breech-coil in the Fraser construction, so there is no fear of the slipping which sometimes took place in the early Armstrong guns.

With regard to the second Armstrong principle already stated, although a series of thin coils help us to distribute the induced strain on a gun by shrinking on each coil separately, the method is open to the serious objection that it is practically difficult to calculate the respective proportionate amount of tension, and consequently the greater the number of pieces in a gun, the more likely some weakness will exist in the mass owing to the undue strain on some of the parts; for instance, a 13-inch gun of original construction (Experimental No. 300) split some of its outer coils while the interior ones remained uninjured, thus clearly proving that there was too great strain on the former. Shrinking on the coils successively was adopted by Sir William Armstrong as a convenient mode of adhesion and not on the distribution theory, which was subsequently enunciated. In the formation of a triple coil it is generally a manufacturing necessity to have the first coil cold before the second bar is wound on, but the third bar is wound on while the second coil is hot; the second and third layers therefore cool and contract simultaneously, and are kept in a state of tension by the first, which they compress to a certain degree. So here also the theory may be carried out, for assuming that iron expands irrespective of its density, the three layers could not recover their natural condition on subsequent heatings.

But "one fact is worth a cart-load of argument;" and one grand

decisive fact bearing on this question was the favourable result of the trials for comparative endurance which 64-pounder and 9-inch specimen guns on the cheap construction underwent, and in virtue of which it superseded the original single coil system of Sir William Armstrong at the close of 1866.

Again, when two years afterwards a "Fraser" 9-inch gun burst at proof, although hundreds of the same sort had stood the proof without wincing, and although it was evident that the gun which failed had a defective steel barrel, nevertheless, to make assurance doubly sure, as well as to ascertain which of the two constructions proposed by Mr. Fraser was the stronger, two 9-inch guns were subjected to a very severe test with most satisfactory results, as I will now explain. I must tell you, however beforehand, that as a measure of precaution, the authorities in 1866 had limited the service of a 9-inch gun to 400 rounds, of which not more than 150 should be with battering charges.

9-inch gun No. 1 consisted of five parts, viz., a thin steel barrel, a *B* tube, two breech coils, and a cascable. It had previously fired 500 rounds with full charges (30 lbs.) and 214 with battering charges (43 lbs.), the vent being at the rear—a fact which causes less strain on the gun than when the vent is further forward. The old vent having been plugged, and the gun vented on the underside in the service position, *i.e.*, about 9½ inches forward, it was subjected to a crucial test of 500 rounds with battering charges at the rate of 50 rounds a day—an ordeal which it accomplished most triumphantly 11th March, 1869. So that this gun fired altogether 1,114 rounds, of which 714 were with battering charges—a great increase on the number of rounds laid down for the service of a 9-inch gun.

No. 2, a new 9-inch gun, of the service pattern, that is, re-inforced with a triple coil, like the gun that burst, was then subjected to the same test as No. 1 had undergone, in order to ascertain which of the two modifications of the new construction was the stronger. It fired 400 rounds with full, and 207 with battering charges, with the vent in rear; it was then turned over, vented in the service position, and the second part of the programme, namely, 500 rounds with battering charges, was commenced. At the 100th round, the impressions showed a faint crack in the steel tube at the crown of the bore. This increased regularly to the 401st round—that is, the 1008th round of all—when the gas escape indicated that the breech end of the tube was split right through. After this the gun fired 41 rounds, and then at length, at the 1049th round, the *A* and *B* tubes were bodily forced about an inch forward. This closed the vent, and consequently put an end to the trial.

The result was deemed most satisfactory, not only because the steel tube failed so gradually, but because the great strength of the outer fabric—the point at issue—was proved beyond all doubt by the gun actually firing 41 rounds after the tube was split through, and yet remaining sound exteriorly.

Both guns behaved so exceedingly well under trial, that the authorities were left in the pleasant dilemma of not knowing which pattern to choose, No. I, with a steel tube 2 inches thick, and re-inforced with

two double coils, surviving the trying ordeal. No. 2, with a steel tube 3 inches thick, and re-inforced with one massive triple coil, did not, it is true, complete the test, but it refused to yield, although its tube was split.

With respect to the precise pattern for future construction, it would, perhaps, have been the safest course to have continued firing No. 1 gun, and then, if it did not blow its breech off (its tube being so thin), or burst explosively without giving ample warning, to have adopted it as the pattern of all the heavier natures. The authorities, however, have decided on constructing 7-inch and 8-inch guns as before, on the No. 2 type, but to make 9-inch guns and upwards, on the No. 1 type.

You will now observe that the adoption of the present construction is not due to the caprice of an individual authority, or to the Parliamentary influence of an inventor, but that it is the ripe fruit of ten years of the most scientific and exhaustive experiments which the artillery world has ever seen.

Present state of the Question.

The question then stands thus:—Up to April, 1867, all our heavy guns were made on the original construction, like the 9-inch gun, Fig. 2, and from that date up to the present nearly all have been made like the 9-inch gun No. 1, or Fig. 3,—*i.e.*, consisting only of four parts, viz., steel tube, cascable, *B* tube, and breech coil, and 7-inch and 8-inch guns will still be made in the same way. Of all these the 9-inch gun is the most important; it is very powerful for its weight, and has been made in considerable numbers; it is therefore taken as a type of the most common form of the present construction, and its manufacture will now be described in detail.

The alteration in future manufacture for 9-inch guns simply consists in having a thinner steel tube and two coils on the breech, instead of one triple one; or perhaps the difference in construction will be more readily remembered by using the familiar illustration, and saying that in the former instance the steel tube is enveloped in "jacket and trousers," whilst in the latter it is thinner, and has "jacket, waistcoat, and trousers." The higher natures are made in the same way, but have a "belt" in addition.

Details of the Manufacture of a 9-inch Gun, Fig. 3.

The gun consists of—

An inner barrel or tube of steel.
A *B* tube.
A breech coil.
A cascable.

The Inner Barrel.

The inner barrel, which when in the gun weighs only 36 cwt., is made from a solid forged cylinder of cast-steel, weighing 67 cwt., which is supplied to the Royal Gun Factories by the contractors,

Messrs. Firth, of Sheffield. Casting is necessary, not only for the purpose of obtaining a sufficiently large block of steel, but also for making the block homogeneous and uniform in density. Forging, or drawing out the cast block imparts to it the desirable properties of great solidity and density.

The block is sent to the Royal Gun Factories, where it is subjected to the following tests and treatment.

A slice is cut off from the breech end and divided in pieces for testing. Some of these are flat bars, 4 inches long and $\frac{3}{4}$ by $\frac{3}{8}$ in section, and others are of the shape usually tested in the machine for tensile strength and elasticity. Three of the former are marked respectively *S*, *L*, and *H*. One end of the *S* or soft (*i.e.*, untempered) piece is gripped in a vice, whilst the other end is hammered down towards it, to ascertain that the steel, by bearing this bending without cracking, is naturally of the mild quality required. The *L* and *H* pieces are raised to a low red, and high heat respectively, immersed in oil, and, when cold, treated in a similar manner.

Whichever of these pieces bears the hammering best, determines the heat at which the whole tube is to be toughened. Should neither piece answer, others at intermediate temperatures are tried, and if all fail, the block is returned to the contractors; but some specimen having succeeded, as is generally the case, two of the remaining pieces—one in its soft state, and the other toughened at the ascertained temperature—are tested for tensile strength and elasticity.

A steel ingot or block which stands all the foregoing tests is "rough turned." In this operation a lip or collar is formed at the muzzle, to facilitate the lifting of the tube in and out of the furnace and oil bath. The fine turning is not done until the *B* tube and breech coil are gauged and ready to be shrunk on.

The block is next bored roughly from the solid, $8\frac{1}{4}$ inches of diameter being taken out by one cut in segmental chips $\frac{1}{8}$th of an inch thick.

The tube thus formed is now ready for toughening in oil. This consists in heating the roughly bored tube (from 4 to 5 hours) to the approved temperature in a vertical furnace, and then plunging it bodily into an adjacent bath of rape oil, in which it is allowed to cool and soak till next day, generally 12 hours or more.

The effect of toughening steel in oil is to increase the elasticity and tensile strength; the process, however, is not without some slight disadvantages, it not only warps the steel a little, but frequently causes the surface to crack. The barrel must therefore be slightly turned and bored, to make it straight inside and outside, as well as to remove any flaws that may have been generated. By these means the cracks are generally removed, but several tubes have been rejected in consequence of flaws still appearing to penetrate to a dangerous depth, and lest there should be any not visible to the eye, the steel barrel is subjected to the water test of 8,000 lbs. per square inch, and if no flaw is detected by the formation of moisture on the exterior, the tube is considered safe and sound. The barrel is left in this state until the *B* tube is ready to be shrunk over it.

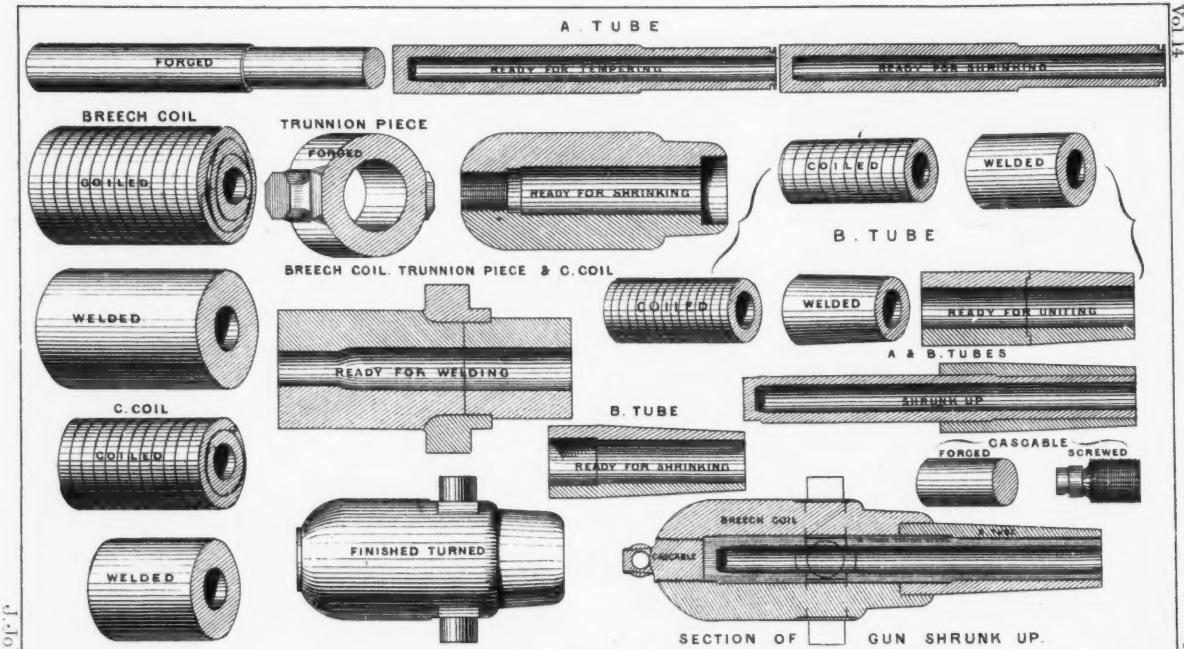


DIAGRAM
to illustrate the most common construction of Woolwich Guns as modified by Mr Fraser.

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The B *Tube.*

The *B* tube is composed of two single and slightly taper coils united together. The first coil is formed of two bars joined together—one 16 feet long and $5\frac{1}{2}'' \times 4\frac{3}{4}'' \times 4\frac{3}{8}''$ in section, the other 33 feet by $5'' \times 4\frac{1}{2}'' \times 4''$. The second coil is also composed of two bars—one 18 feet by $4\frac{1}{2}'' \times 4\frac{1}{2}'' \times 4''$, and the other 31 feet by $4'' \times 4'' \times 3\frac{1}{2}''$.

The two coils, being made and welded in the usual way, are faced and reciprocally recessed to the depth of about one inch, and then united together endways by expanding the faucet of one coil by heat, and allowing it to shrink round the spigot of the other. This sticks the two coils sufficiently tight together to admit of the tube thus formed being placed upright in a furnace, whence, when it arrives at a white or welding heat, it is removed to a steam hammer, and receives on its end six or seven pressing blows which weld the joint completely. The weight of the tube in this rough state is about $55\frac{1}{2}$ cwt., but when finished, as it is on the gun, it only weighs 31 cwt.

The *B* tube is next "rough turned," in which process a rim is formed near the muzzle for the convenience of lifting the tube in "shrinking." After this, the tube is "rough" and "fine bored" in the same horizontal machine.

The interior of the *B* tube having thus been brought to the degree of smoothness requisite for close contact with the steel barrel, is gauged every twelve inches down the bore, and also at the shoulder. To the measurements thus obtained, the calculated amount of shrinkage is added; a plan is made out according to which the exterior of the *A* tube (or rather that portion of it on which the *B* tube is to go) must be turned down, in order that it shall be exactly larger than the bore of the tube by the required amount of shrinkage at the respective parts.

The plan is made on a slip of paper, and together with a corresponding series of accurately measured horseshoe gauges, is furnished to the turner, who turns down the muzzle end of the *A* tube accordingly.

The reason an *inner* tube is turned to suit an exterior one, instead of the latter being bored to suit the former is, that it is much easier to turn than to bore to very exact dimensions, on account of the great command which the operator has over the turning lathe, and the facility he has of testing his work by gauges, and correcting it by emery powder and oil.

The Breech Coil or Jacket.

The breech coil or jacket is composed of a triple coil, a *C* double coil, and a trunnion ring, made and welded together as follows:—

The triple coil is made of three bars all of the same section, viz.—$4\frac{1}{2}'' \times 4\frac{1}{2}'' \times 4''$, but differing of course in length, the first or innermost one being 78 feet, the second 118 feet, and the third 158 feet in length, the middle one being coiled in the reverse direction, so as to break joints. In order to weld its folds, it is placed in a furnace for about ten hours, at the end of which time it is at a welding heat, whereupon it is rapidly transferred to a powerful hammer, and receives

a few smart blows on its upper end, which close the folds longitudinally. A mandril somewhat larger in diameter being then forced down it, it is turned on its side, and well hammered all round to make it dense. It is replaced in the furnace for about six hours, and the same process repeated at the breech end, but with a smaller mandril.

When cold, the ends are faced and the outer coil is turned down at the muzzle end to form a shoulder 14″ long for the reception of the trunnion ring.

The C coil is made of bars of the same section as those used for the triple coil. The inner bar is 46 feet in length, and the outer one 69 feet. This double coil being welded, has a shoulder formed on the lower end about 9 inches long and $\frac{3}{4}$ inch deep, so that it may overlap the trunnion in the welding.

The trunnion ring is made like all wrought-iron trunnion rings—namely, of slabs of iron consecutively welded together on the flattened end of a porter bar, and gradually formed into a ring by means of, first, a small iron wedge, which is driven through the centre and punches an oval hole, and then by a series of taper mandrils increasing in size, which make the hole sufficiently large and round. The trunnion ring has to be heated for each punching, and the occasion is used to hammer the trunnions roughly into shape, one of which is in continuation of the porter bar. Eventually the ring is cut off from the bar by means of strong blunt hatchets of steel hammered through it. The trunnion ring is next roughly bored out.

All three parts (breech coil, *C* coil, and trunnion ring) being thus prepared, the trunnion ring is heated to redness, lifted by a crane, and dropped on to the shoulder of the triple coil, which is placed upright on its breech end for the purpose.

While the trunnion ring is still hot, the *C* coil is dropped down upon the front of the triple coil, through the upper portion of the trunnion ring which was left projecting. The trunnion ring thus forms a band over the joint, and in cooling contracts round the two coils, and grips them sufficiently tight to allow of the whole mass being placed bodily in a furnace, where it is raised to a welding heat in about thirteen hours (see diagram, breech coil, trunnion ring, and *C* coil ready for welding, Plate XIX).

The glowing mass is then quickly placed on its breech end under the most powerful hammer in the department. Six or seven blows on the top suffice to amalgamate the three parts together; but to make the welding more perfect on the interior, as well as to obviate any bulging inside, a cast-iron mandril somewhat larger than the bore is forced down to within 20 inches of the breech end, a series of short iron plugs being used to drive it down. The mass is then reversed, and the mandril is driven out with the same plugs, which have fallen out in the tilting over.

The rough jacket thus made weighs over 16 tons, but this weight is reduced to 9 tons by the turning, rough and fine boring, &c., which are necessary to bring it to the proper size and shape.

The body is turned in a very powerful lathe, weighing, with its

foundation, 100 tons, to the required shape. The operation takes sixty hours; consequently all the four big lathes, which are in a row, may be often seen at work together, and a fine mechanical spectacle it is.

It being impracticable to turn down the trunnion belt in a lathe, it is slotted smoothly down by a self-acting vertical machine with a double motion, one of which moves the jacket round for a fresh cut at every stroke of the tool which the other works up and down accordingly.

The trunnions themselves have yet to be turned down to shape; so the jacket has to be moved for the purpose to another machine—a break lathe—in which it is made to revolve on the axis of the trunnions, while the sliding cutters act on their surface.

The jacket is next rough and fine bored in a machine like that used for the *B* tube, but stronger, and the front of the *C* coil is recessed on the inside to a depth of 9 inches, and broad enough to overlap the *B* tube.

Finally, the female thread for the cascable is cut by a machine in which the jacket revolves horizontally, while the cutter is fed forward by a copying screw—one pitch for every revolution of the jacket.

Building up the Gun, or shrinking the parts together.

The steel barrel and *B* tube being prepared for one another as described, are shrunk together in this manner:—The *B* tube is placed on a grating, and heated for about two hours by a wood fire, for which the tube itself forms a flue, until it is sufficiently expanded to drop easily over the muzzle end of the steel barrel, which is placed upright in a pit ready to receive it. The *B* tube is then raised, and the ashes, &c., being brushed from the interior, is dropped over the steel barrel by means of a travelling crane overhead. During the process of shrinking, a stream of cold water is poured into the steel barrel, to keep it as cool as possible, the water being supplied and withdrawn by a pipe and syphon at the muzzle. A ring of gas is placed at the muzzle or thin end of the *B* tube, to prevent its cooling prematurely, whilst jets of cold water play on the other end, and are gradually raised to the muzzle, for the purpose of cooling the whole tube consecutively from the breech end, which it is desirable should grip first, to ensure a tight fit at the shoulder. Moreover, were both ends allowed to contract simultaneously, the intermediate part of the tube would be drawn out to a state of longitudinal tension, and weakened accordingly.

The *A* and *B* tubes shrunk up (see diagram), are placed in a lathe, and while one cutter fine-turns the *B* tube to its proper shape and dimension, another cutter fine-turns the breech end of the *A* tube according to the plan of the breech coil, which has been made out on a principle already explained.

The half-formed gun, composed of *A* and *B* tubes shrunk up, being next placed standing on its muzzle in the shrinking pit, the jacket is heated for about ten hours, and shrunk on in the same manner as the *B* tube; it is however (being nearly of the same thickness throughout),

allowed to cool naturally, and the cold water has to be forced up, fountain fashion, into the bore of the gun by a jet round which the muzzle rests.

The process of building up a 9-inch gun is very similar. There are, however, three shrinkings instead of only two—viz., the coiled breech-piece on the breech-end, the *B* tube on the muzzle end of the barrel, and then the outer breech coil over the inner one.

Processes after the Gun is built up and before proof.

These are :—

1. Screwing in the cascable.
2. Engraving the Royal cypher.
3. Fine-boring.
4. Second rough-cutting of chamber.
5. Finished boring.
6. Broaching of bore, and finishing of chamber.
7. Lapping.
8. Rifling.
9. Temporary venting.

(1.) *The cascable* is made of the best scrap iron. It is first forged into a simple cylinder; it is then turned, and a bevel thread cut on it. The button is turned on it, and a hole (which is afterwards enlarged into the loop), is drilled through one end, for the purpose of screwing it into the gun. The operation of screwing in the cascable requires great care, for the front of it must bear evenly against the end of the steel barrel, and in order that this may be the case, the end of the tube is smeared with red lead and the cascable screwed in tentatively, then unscrewed again, and filed down on the prominent parts, which are indicated by the absence of the red lead. This is repeated several times, until the equal distribution of the lead on the front shows that it bears evenly against the steel barrel.

At this stage, one round of thread is turned off the end of the cascable, so that there may be an annular space there, which in connection with a channel now cut along the cascable and across the thread, will form a gas escape, or tell-tale hole, in case the steel barrel should split at the end. The channel is about $\frac{3}{8}$th inch broad, and extends $\frac{1}{10}$th inch below the thread. In all guns made before the 1st September, 1869, the channel comes out directly under the loop; but in guns made since that date, it will be found at the right side of the loop, where it may be more easily noticed. The channel ought to be kept clear, and should the barrel be split at the end, some gas may be seen issuing from the hole; it is therefore advisable to keep an eye on this hole, and to cease firing, should it give warning.

When at length the cascable fits properly, it is screwed in, and to prevent its moving, a hole $2\frac{1}{2}$ inches long and $\frac{3}{4}$ inch in diameter is drilled and tapped through the male and female threads in a slanting direction on the left side, and a plug is screwed in.

(2.) While the cascable is being prepared, Her Majesty's mono-

gram is engraved in front of the vent, the outline being marked on the gun by means of a perforated brass plate, rubbed over with charcoal.

(3.) The gun is next removed to the boring mill, where it is fine-bored to 8″·9.

(4.) The chamber is next roughly bored out with the same boring head as before.

(5.) The finished-boring to 8″·997 is then performed.

The fine-boring and the finished-boring are effected with the boring-head used in the second rough boring, and together occupy twenty-six hours.

(6.) In each boring the cutters wear a little during the operation, so that the bore becomes slightly taper towards the breech. This is of no consequence in an outer tube, as the exterior of the inner one can be turned accordingly, but the bore of the gun must be cylindrical, so broaching is employed—that is, boring the barrel by means of a cylindro-conoidal head, fitted with four long cutters at right angles to one another, and slightly tapering. The cutters are edged on the front as well as on the side, as the chamber is also finished off at this time, and for this latter purpose there is also a peculiar centre cutter for the very end of the bore.

(7.) Still, however, the bore is not yet truly cylindrical, and "LAPPING" is resorted to. In this no cutter is used, but a wooden head, covered with lead and smeared over with emery powder and oil, is worked up and down at those portions of the bore which are indicated by the gauges as imperfect.

(8.) The 7-inch M.L. guns are RIFLED with a uniform spiral—*i.e.* with grooves having the same amount of twist at every point of the bore; and all the higher natures with a uniformly increasing spiral—*i.e.* uniformly increasing from the breech to the muzzle. The advantage of an increasing spiral is, that the inclination of the grooves, being little or nothing at the breech, the projectile's initial motion is not checked by any resistance offered to the studs. The projectile therefore moves quickly from its seat, and relieves the breech a good deal from the strain of the discharge.

The groove is of the "Woolwich" shape, 1″·5 wide and 0″·18 deep, with concave edges. It is the same width for all natures, but it is a little deeper for the 10-inch and 12-inch guns. The number of course varies with the calibre, 7-inch guns having three, 8-inch four, 9-inch six, 10-inch seven, and 12-inch nine.

As a rule, about two calibres in length is left plain or unrifled for a powder chamber. The exact proportion is not fixed. The unrifled part, however, should be no shorter than actually necessary to prevent a detrimental air space between the smallest charge used and the base of the projectile, as the grooving tends to weaken the barrel very much, and the seat of the charge should be the strongest part of the gun.

(9.) Previous to the 23rd January, 1868, rifled M.L. guns were left altogether unvented until after proof, at which they were fired by means of electric wires passed in at the muzzle. Since that date, all

guns are drilled and tapped before proof, and fired through a removable steel vent, which is unscrewed after proof and replaced by the permanent vent; the object of this is to prevent the proper vent being strained by the large proof charge.

Proof.

Before a gun is proved, gutta-percha impressions are taken of the whole length of the bore in the four quarters. The gun is then proved with two rounds—the projectile being equal in weight to the service one, but flat-headed, for 7-inch guns and upwards, in order that it may penetrate as little as possible into the butt, and the charge being 1¼th the weight of the battering or highest charge used in service. The gun is fired in the open by means of an Abel's electric tube, connected with a magneto-electric battery in a bomb-proof shed.

With the early rifled guns much larger charges were used at proof, and then service charges and a double-weighted shot were used for some time; but this was found to strain the gun too much, and the Ordnance Select Committee having thoroughly investigated the matter, and having obtained the particulars of proof of guns in France, Belgium, Holland, Austria, Spain, Saxony, Denmark, America, Wurtemberg, Bavaria, and Sweden, came to the conclusion that the proof should be based on the highest charge which the gun will have to bear on service, and recommended the present proportionate charge for rifled M.L. guns, which was approved 13th July, 1864.

After proof, water is force-pumped into the bore, with the pressure of 120 lbs. to the square inch. This was instituted for guns with wrought-iron barrels to ascertain that the breech was perfectly closed, and is still continued in the case of solid-ended steel barrels, to make sure that the end has not been split in proof. After this the gun is cleaned, and gutta-percha impressions of the bore being taken as before, the two sets of impressions are compared, to ascertain that no flaw of a serious character has been developed by proof. If any defect appears of which there is even the slightest doubt, the gun is subjected to five more rounds with service charges, and if after that the flaw does not appear to have increased, the gun is passed.

Processes after Proof and before Issue.

(1.) Lapping.
(2.) Obtaining preponderance and weight.
(3.) Lining.
(4.) Sighting.
(5.) Venting.
(6.) Marking, and the "marks" denoting pattern.
(7.) Fixing on elevating plates and small fittings, sloping sides of cascable, and scoring breech.
(8.) Painting and lacquering, and final inspection.

All the above processes, except the last, are performed in the one

workshop (the sighting room), and generally, but not necessarily, in the exact order given.

(1.) Every gun is LAPPED after proof, for the purpose of removing any little burs which may be thrown up on the edges of the grooves by the impetuous proof rounds.

(2.) The meaning of the term "preponderance" as applied to modern guns, is the pressure which the breech portion of the gun, when horizontal, exerts on the elevating arrangement.

The preponderance of heavy guns should be as small as possible, so as not to interfere with the easy action of the elevating arrangement. 5 cwt. was assigned for 9-inch guns, and between 5 and 6 cwt. for the heavier guns; but by a recent order, 13th April, 1869, all sea-service guns of 18 tons and upwards are to have no preponderance, and as this is practically impossible, it is further stated that anything under 3 cwt. will be considered as none.

The actual *weight* of each gun is taken by means of a strong steelyard, to the short arm of which the gun is slung by the trunnions.

(4.) M.L. guns are *sighted* like B.L. guns on both sides, and with the same kind of tangent sights; but M.L. guns have in addition short centre, hind, and fore-sights. They have therefore three pairs of sights attached to the gun, and besides these there is a wood scale for use on board ship.

(5.) *The vent* in rifled M.L. guns does not enter near the end of the bore as in S.B. guns, but at a point two-fifths the length of the service cartridge from the end, for it has been proved by experiment that by igniting the cartridge at this point, the maximum initial velocity is obtained.

Up to 1st November, 1868, the vent bushes were the ordinary copper cone vents, let in perpendicularly, but at that date a new kind of vent (proposed by Major Palliser) was inserted in the 10-inch guns. This vent consisted of a steel bush, lined with copper, screwed in from the exterior, against a platinum tip screwed up from the interior, the tip having a flange or button-shaped head projecting into the bore to close the joint; and instead of entering the bore vertically, it was fixed upon the side* of the gun at an angle of 45° to the vertical axis, in order that it might be more easily served (see List of Changes, 1st December, 1868). It was subsequently decided (25th November, 1868), that all wrought-iron guns of 7-inch calibre and upwards should have similar vents, but let in vertically as before, except in the case of guns of 10-inch calibre and upwards, whose size would render the vertical position awkward.

This was acted on for a short time, but the vents not proving satisfactory, the employment of the platinum tip was suspended, and steel vents lined with copper were used; but as these too did not answer expectations, all the big guns are now vented with copper specially hardened, the letter *H* being stamped on the top to indicate the fact.

* The vent is on the right side of the gun if intended for broadside purposes, but if for a turret gun, the vent is placed on the right or left hand side as convenience demands.

The matter, however, is not yet settled; platinum-tipped vents, without the flange, are under trial. The more powerful the gun, the greater is the wear and tear on the vent. Simple copper vents are most satisfactory for guns up to a certain size, and in spite of the softness of this metal, many think it will answer for very large guns quite as well as a more costly material.

This difficulty about vents is only one of the many which have to be overcome before we can obtain heavy guns perfect in every respect.

(6.) In addition to the *marks* made in lining, and the Royal cypher before mentioned, the broad arrow and actual weight are stamped behind the vent, and two parallel lines are cut across the vent field to indicate the unrifled space. The material of the inner barrel (for example *Firth's steel*) is stamped on the face of the muzzle, as is also the number of the steel barrel as entered in the registry of manufacture.

On the left trunnion are the initials R.G.F., the register number of the gun, the numeral signifying its pattern, and the year of proof. The register number is that by which the gun is registered in the Department records; it indicates also the number of that nature manufactured. With respect to the numeral, the word "pattern" was superseded by "mark," and the construction of guns has been designated accordingly since 20th April, 1868.

(7.) *The extra fittings* or appurtenances of M.L. guns are very few and simple when compared with those for B.L. ordnance. They are limited to gun-metal elevating plates for guns for both services, guide-plates, and friction tube pins for sea service, and muzzle studs and shot bearers for land service.

(8.) The exterior of the gun being well cleaned, receives one coat of "Pulford's magnetic *paint*," which is now used for all iron guns instead of anti-corrosion, to which it is superior in point of cheapness and durability. The bore receives one coat of the usual *lacquer*.

Finally. The gun and all its fittings having been inspected, and found in exact accordance with the sealed pattern, is issued for service.

I have done little more than enumerate the processes of construction, as I have not time to describe them, but I may state generally that the manufacture of one of our big guns is a triumph of forge craft, involving a combination of strength and science in the mechanics; power and accuracy in the machines.

England has always excelled in smith work, but we can imagine the admiration and surprise which a cunning worker of old—nay, even which a scientific engineer of the last generation would express—could he but visit the Royal Gun Factories, and follow through acres of furnaces and machinery, the various processes in the manufacture of our ordnance. Here, amid the glow of a dozen fires, he would see certain quantities of scrap iron taken from an incongruous pile of old articles—such as horseshoes, linchpins, bolts, nuts, screws, locks, keys, musket barrels, door knockers, hooks, crooks, &c., &c., which a thousand different smiths must have forged—and put into furnaces to replace others just brought out at a white heat, and which he would see pressed as if they were made of cheese into "blooms" or oblong

blocks, and then, while still hot, passed through rolls (the fly-wheel of which weighs 50 tons), and formed into flat bars; other similar bars he would see made from puddled cast-iron in a like manner, but with more trouble and with a more sparkling effect, and then several of these flat bars sandwiched together, raised to a white heat, and passed through the narrow portion of the rolling mill to form one long, thick bar—the unit of the gun.

The process of welding several of these unit bars together one by one would appear familiar work; but the length of the bar thus obtained, 270 feet perhaps, would amaze him, especially when he saw it afterwards drawn at a bright heat out of a long furnace, and by means of machinery wrapped spirally round an iron mandril as easily as a cable is wound round a windlas, and then a similar bar wound round over the first, and then a third one over both.

He would see the immense coil thus created, hoisted from the furnace as white as snow and welded longitudinally so as to close its folds, and he would no doubt feel jealous of the ease and power with which the ponderous steam hammer performed a task which could not be accomplished by any number of sledges wielded by human arms. Nor would his surprise be less on seeing 7 inches in diameter of these massive forgings peeled off in a lathe weighing, with its foundation, 100 tons; nor on seeing 11 inches in diameter bored out of a solid block of steel: nor the subsequent processes by which the bore becomes as smooth as glass, and so exact in dimensions that, when tested by micrometers showing a thousandth of an inch, no error would be perceptible.

Finally, he would see the wrought-iron casings expanded by heat and shrunk over the steel barrel—thus making a gun capable, he would be told, of sending a projectile weighing over a quarter of a ton through an iron plate a foot in thickness and half a mile away, and moreover that six thousand tons weight of guns of various calibres could in one year be produced in the Royal Gun Factories!

It is thus our beautiful guns are made—beautiful not in the sense of exterior ornamentation like the Oriental guns, which are adorned with quaint figures and hieroglyphics, nor yet like our cast guns of the last century, which are ornamented with astragals, fillets, and ogees, but beautiful in their strength compared with their weight, beautiful in the simplicity and durability of their construction, beautiful in their excellence of range, accuracy, and penetration. I do not mean to say that we have reached the *ne plus ultra* in ordnance—I hope we shall still continue marching on, until artillery takes the foremost place amongst the sciences—but I mean to say that we have the best and cheapest system of heavy ordnance.

Marked progress in Heavy Artillery during the last five years.

In conclusion, I would remark that the tests and trials bearing on this question, while exemplifying the pains taken to obtain the best war *matériel*, cannot fail to satisfy the most sceptical that the present construction of our heavy guns is sound and durable, and the general

result must be gratifying to the authorities who approved of the system five years ago.

Indeed the past lustrum must always be a marked epoch in the history of our heavy artillery; for 7-inch, 8-inch, 9-inch, 10-inch and 12-inch guns have been made in numbers, and the system is applicable to still larger guns—nay, tracings have been actually furnished of 700-pounders of 35 tons, 800-pounders of 40 tons, and 1000-pounders of 50 tons, and the guns can be put in hand with every prospect of success whenever the Secretary of State for War thinks fit to order them.

But this progress in the production of heavy ordnance cannot be fully appreciated, unless the difficulty of perfecting a more powerful gun than previously existed, is properly considered and understood. In the first place, the practicability of manufacture and the durability of structure must be ascertained. The weight, calibre, length, system of rifling, weight and shape of projectile, &c., &c., must be all scientifically calculated so as to ensure excellence in range, accuracy, and penetration: and then each and all of these constructional details are liable to alteration should the thorough trial of a specimen gun at Shoeburyness render any amendment advisable. The sights too must be made, graduated, and adjusted, and finally the gun has to be vented—no easy task in the higher natures, as already observed.

Mr. Reed, Chief Constructor of the Navy, maintains that corresponding progress has been made in our ship building:—

"It is but five years ago that Parliament was discussing the practicability of carrying 6½ ton guns at sea, especially in broadside ships; we have now 12 ton guns fought at sea with perfect ease, in many of the broadside ships of the Mediterranean and Channel squadrons, and the 'Hercules' has long been cruising about, both at home and abroad, with 18 ton guns worked most satisfactorily at the broadside in ports 11 feet above the sea, and with a horizontal range of fire which no unarmoured ship's broadside guns possess. The 'Monarch' has cruised successfully in heavy weather with 25-ton guns mounted in turrets. None but those who are hopelessly prejudiced can now doubt that, whether they be placed in turrets or out of turrets, the largest guns can be worked successfully with terrible effect at sea, and in heavier weather than the small guns of old could be fought."*

Surveying the whole question, therefore, by the calm light of facts and figures, I think it may fairly be asserted that, up to the present time at least, England has not lost her naval supremacy.

Captain WHEATLY, R.N.: I only wish to remark, after this very interesting account of ten years' skill and science applied to heavy guns, that it is no exaggeration to say that, as compared with torpedoes, your heaviest guns bear about the same proportion as the old bow and arrow do to the modern rifle. I do not know whether you remarked the experiment that was made between the "Camel" and the "Royal Sovereign" about a month ago. The "Royal Sovereign" in smooth water was struck eleven times by the torpedo, and could only bring her guns to bear twice on the "Camel." The chief requisite for a torpedo vessel is speed. Let but a torpedo vessel come near the iron-clad, however large, woe betide her; her fate is just what that of the hare

* "Our Iron-clad Ships."—1869.

would be when within spring of the hound. As an example of the great destruction that might be caused by one of these vessels, you have only to imagine a torpedo vessel armed with 200 torpedoes among the Anglo-French fleet crossing from Varna to the Crimea, or among the Federal fleet at the attack on Fort Fisher; the general state of affairs would have been very much changed.

Captain WILLIAM ARTHUR, R.N.: You referred to the decreased initial velocity of rifled in comparison with smooth-bore shot, and you attributed it to the rifling of the gun. Do you not think it might be equally attributed to the decreased proportion of the powder used, to the weight of the projectile?

Captain STONEY: I believe I said so.

Captain ARTHUR: In regard to altering the nature of the iron which was formerly used in the construction of the gun, if there was any superfluous strength in the gun which might be dispensed with, do you not think it might have been employed in using a larger powder charge and getting an increase of initial velocity. My question is rather, whether inferior quality of iron was substituted because you had too much strength in the gun?

Captain STONEY: It was uselessly expensive outside; the exterior portion of the gun was uselessly strong.

Captain ARTHUR: But the same quality of iron is retained in the A tube?

Captain STONEY: Yes; but now only a few heavy rifled guns have wrought-iron barrels.

General BOILEAU, F.R.S.: With regard to the construction of the gun I wish to ask a question. The lecturer has described most satisfactorily the way in which the butt-joint forming the two parts of what he calls the jacket are brought together into perfect union by being welded at a white heat. I beg to ask whether the pieces, which the lecturer has called the jacket, but which, as it contains the breech end of the gun, perhaps I may be permitted to call the breeches, whether the breeches brought into contact with the trowsers which form the butt-joint are left merely as a butt-joint, or whether the breeches and trowsers are welded together as in the two parts of the jacket? In regard to what the lecturer has said about the increased size of guns and weight of projectiles, I think we have heard a similar intimation on the part of Mr. Reed at a neighbouring Institution, when describing the thickness of armour-plating upon vessels constructed to meet these projectiles. He told us at the Royal Institution that he had an undivulged plan for an armour-plated vessel to carry iron plates, 24 inches in thickness. Now, I think the race will be hard between guns and armour-plates if vessels of this kind should ever be built and sent afloat. But it will be for experiment, as Captain Stoney has told us, at Shoeburyness to decide whether a thousand-pound projectile will be able to pierce a 24-inch armour plate. I have been extremely interested in the description of the manufacture of these guns, and can quite appreciate what the lecturer has said, that we stand far beyond all nations both in the power, in the endurance, in the range, in the accuracy, and in the projectiles of our guns; and, as in the past, so I have no doubt in the future, as long as ships are afloat, we shall continue to maintain our supremacy on the ocean.

Captain WHEATLY: I beg to say, with regard to the size of ships and the weights of ships, that as it is much easier with a pistol or rifle to hit a barn door than to hit a waistcoat button, so the size of a ship will only make her a better mark for a torpedo; and the weight will only carry her more quickly to the bottom. Both the Russians and the Americans have torpedoes.

Captain ARTHUR: One other point I should like to refer to. It is with respect to the venting of the gun. You mentioned that you thought hardened copper might be used for venting. I have tried hardened copper, and have a clock which was constructed for some magnetic experiments, the works of which even to the main spring, are of that metal. It has been going for some time, and works in a very satisfactory manner. I have no doubt that copper could be hardened to any extent. I see in the drawings the vent does not appear to be screwed into the gun. Is the omission of the thread intentional?

The CHAIRMAN: If no other gentleman has a question to ask, I will now call upon Captain Stoney to reply.

Captain STONEY: I am scarcely in a position to go into the torpedo question. I

do not know what progress has been made in that direction, but I hope we shall have as good torpedoes as other nations. I am sorry to say that I am confused with General Boileau's breeches and trowsers.

General BOILEAU: Call it jacket if you please. My question is, the two joints that butt, are they butted or are they welded together?

Captain STONEY: The trowsers are put on quite separately: there is no welding.

General BOILEAU: You described the parts of the jacket as welded; then the jacket is put on to the barrel at the breech end, and the trowsers are put on in front. Are the two ends merely left butting against each other, or are they welded together?

Captain STONEY: They butt together, a portion of the jacket overlapping the trowsers; there is no welding between them.

General BOILEAU: They are held on by shrinkage?

Captain STONEY: They are held on by shrinkage. Nor is there any great strain on the joint, the steel barrel prevents any action between the two. The hardened copper vent is screwed into the gun, but in some of our guns it is only screwed partially. The hardened copper is found to withstand best the chemical and mechanical action of the powder gas.

Colonel JERVOIS, R.E.: I wish to make one observation with reference to the remark of the gentleman who spoke about torpedoes. I merely rise to say that, whilst I have a strong appreciation of the great value of torpedoes, the question of their application should be considered distinctly from that of the construction or application of heavy artillery. The ship must come to the torpedo if the submarine mine is to take effect, whilst the shot from the gun can be sent to the ship, and will take effect at even two or three miles distance. The torpedo must be admitted by all, to be a most valuable and important accessory in the defence of harbours, but the big mine under water cannot supply the place of the big gun above water.

The CHAIRMAN: I will now ask the meeting to return thanks to Captain Stoney for his very interesting lecture. He has gone elaborately into the construction of artillery. I think he has said something about his first appearance. Many people who make their first appearance in a lecture theatre would be very happy if they could make as good an appearance as Captain Stoney has done.

Lieutenant BROOK, 45th Regiment, exhibited a revolver which he had procured in the United States, and which he said was about to be introduced into the Service there, the distinctive feature of which arm is, that the surface of the metal is coated with nickel by electro process, which protects the arm from rust.

LECTURE.

Friday, April 1st, 1870.

FIELD MARSHAL HIS ROYAL HIGHNESS THE DUKE OF CAMBRIDGE, K.G., G.C.B., &c., &c., Commanding-in-Chief, in the Chair.

THE LAST CAMPAIGN OF HANOVER.

By Captain H. BRACKENBURY, R.A., Professor of Military History, Royal Military Academy, Woolwich.

When I received the invitation of the Council of this Institution to lecture here, the choice of the subject being left to myself, I had recently returned from visiting the theatre of the war of 1866 in Western Germany, and from studying on the spot those operations of General Falckenstein which had led to the dispersion or the defeat of three several armies, and the clearance of the whole of Germany, north of the Maine, from the enemies of Prussia; and on my return to England I had been much struck, not only with the absence of correct knowledge as to this campaign in Western Germany, but with the amount of wrong information which appeared to exist, more especially as to that earlier portion of the campaign which took place in Hanover.

I have here a well known book, which may perhaps be fairly said to represent the historical and geographical knowledge of a large portion of my fellow-countrymen on this subject—"Murray's Handbook." Turning to Langensalza I find it described as a town "giving name "to a battle in 1866, in which the Hanoverian army, attempting to "escape south, were defeated by the Prussians." There never was a greater libel upon a gallant nation; and, indeed, there is something almost repugnant to one's feelings of fair play in the assumption which seems to underlie this statement, and many others which I have seen, that the Prussians must have won every battle that they fought, and that their strategy and their tactics must have been perfect in every portion of that war. I thought, then, I might do something towards the cause of historic truth were I to accept the invitation of the Council, and to tell here the plain, unvarnished, true, story of the campaign of Hanover, as I derive it from the closest comparison of official accounts, both Prussian and Hanoverian, with such other trustworthy data as I have been able to collect, and from the closest study of the ground on which the campaign was fought.

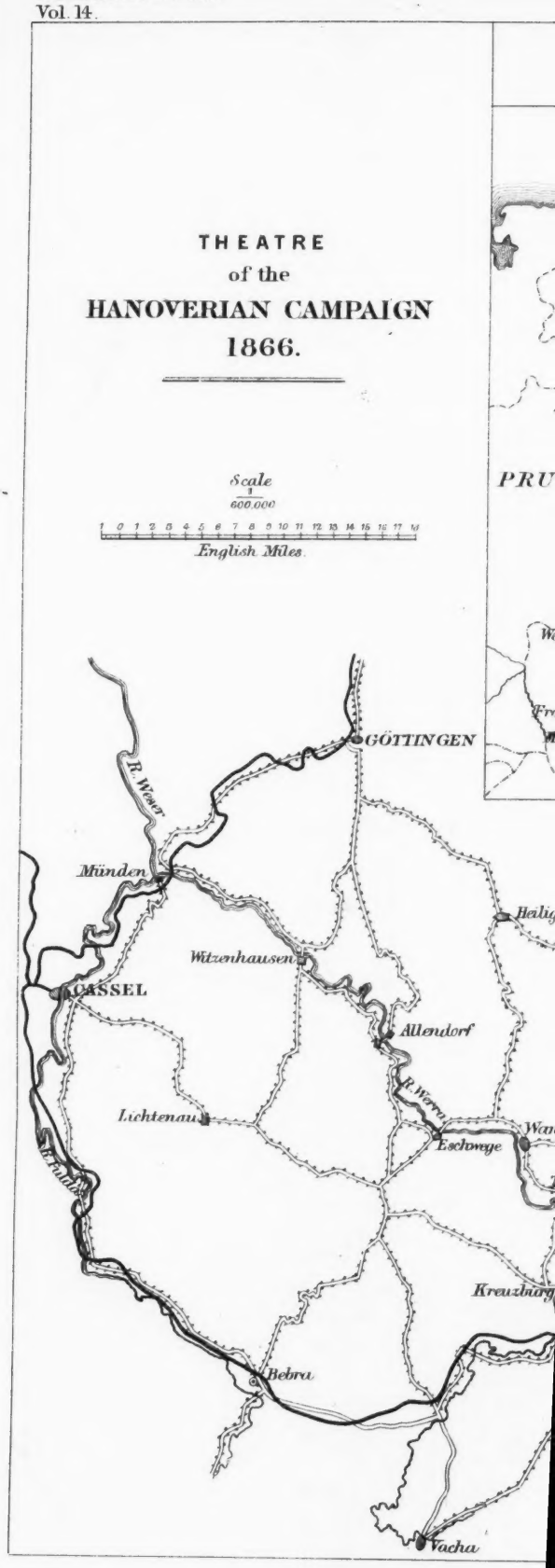
Passing entirely over all the political events which led to the outbreak of this war, we arrive at the 14th of June, 1866. On that day

a vote of the Federal Diet was passed—hostile to Prussia, and decreeing the mobilisation of the Federal Army against her. At once the Prussian Ambassador declared the Diet dissolved, and on the 15th, Prussia, having previously telegraphed a summons to Hanover to accept her terms, declared war against Hanover, Saxony, and Hesse-Cassel.

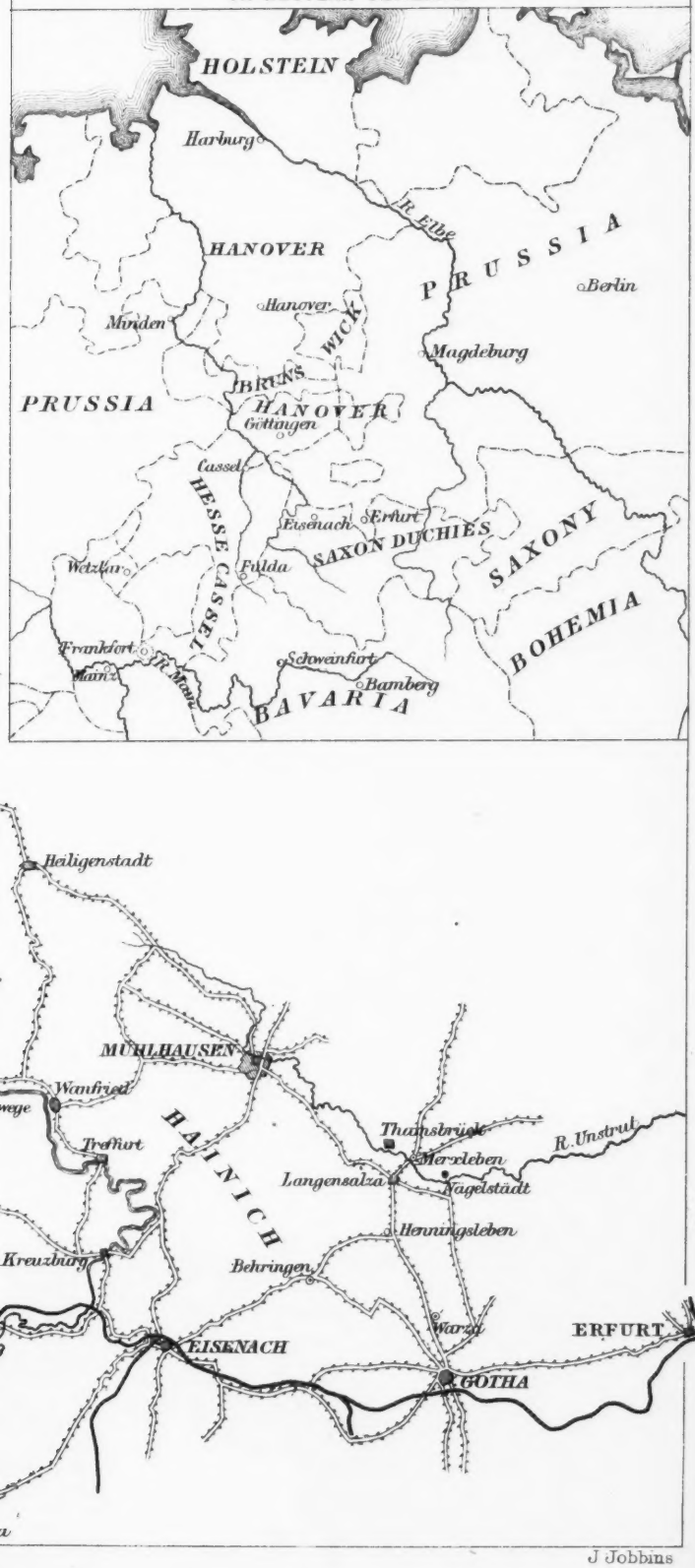
The importance to Prussia, with the view to subsequent operations against the south, of first making herself mistress of these three countries, was very great. Hanover lies directly between the western and eastern provinces of Prussia, and, in an enemy's hands, interposes an effectual bar to the passage of troops between them; in like manner Hesse-Cassel interposes between these western and eastern possessions; and, moreover, through Cassel passes that railroad which is the great artery of communication between those provinces. Of Saxony I need not now speak.

At once, after her declaration of war, Prussia put her troops in motion. At this time the army of Hanover was in that unfortunate condition which is known as a "peace footing." Large numbers of her infantry were on furlough; her cavalry and her artillery were perhaps in a somewhat better condition than usual, because it was the season of the summer drills, and they happened to be called out for regimental exercise; but they had only horses for a peace establishment. Neither cavalry nor artillery had the proper number of horses required for them to take the field, and some of the guns were actually led out to fight this campaign horsed with horses from the King's stables, and driven by the King's stablemen. At the time of this declaration of war, and of the immediately subsequent movement of Prussian troops, the Hanoverian army was in a state of dislocation, as it is termed, though immediately after the decree of mobilisation had been passed in the Diet on the 14th of June, it had been ordered that the troops should be assembled at certain points by the 23rd June. But all the arrangements for the mobilisation of the army pointed towards concentration in the northern portion of the kingdom. There were no arrangements whatever for the assembly of troops in the south; there were no magazines, there were no stores of supplies, there was, in fact, nothing ready for such a concentration. But when Hanover saw that the Prussian troops were about to advance from Minden towards Hanover, when she saw that troops were actually in the north of her own territory, as some of them were, before war was declared, it was impossible for her, as she well knew, to concentrate in time in the north, and therefore the order was issued for the concentration of the whole army in the extreme south of the Hanoverian territory, at the well known university town of Göttingen.

The troops with which Prussia was about to commence this campaign consisted, in the first place, of a division under the command of General Gœben, which was stationed at the Prussian fortress of Minden, 14,000 strong. There was also a corps under the command of General Manteuffel, which was, as I have already said, at the outbreak of this campaign—at all events some portion of its troops were—on Hanoverian territory. When the difficulties had arisen with Austria, and Prussia had occupied Holstein, the Austrians


THEATRE
of the
HANOVERIAN CAMPAIGN
1866.
Scale
1
600.000
English Miles
PRU
GÖTTINGEN
R. Weser
Münden
Witzenhausen
CASSEL
Allendorf
R. Werra
Lichtenau
Eschwege
Kreuzburg
Bebra
Vacha

Sketch Map
OF THE THEATRE OF THE CAMPAIGN OF 1866 IN WESTERN GERMANY.



J Jobbins

had obtained permission for their brigade Kalik to march through Hanover to the south, and the Prussians had followed this by a request for permission for their troops also to pass through Hanoverian territory to Minden. The permission had been granted, General Manteuffel had taken advantage of it, and had actually, before the war was declared, brought some of his troops across the Elbe to Harburg. In addition to this corps of 14,000 of General Manteuffel's in the extreme north, and the corps of 14,000 under General Gœben at Minden, 20,000 troops under the command of General Beyer, which were in the small Prussian enclave at Wetzlar, received orders from the head-quarters at Berlin to move at once on Cassel. General Falckenstein was placed in command of the two divisions which were to advance from Minden and from the Elbe upon Hanover, with orders to operate against the Hanoverian Army, to disarm it, and prevent its taking any further part in the war, always bearing in mind that he would be required for subsequent operations in the south. The advance of these troops commenced immediately after the declaration of war. Beyer, moving in a north-easterly direction, had occupied Cassel, and had drawn together the whole of his troops there by the 20th of June, the small Army of the Elector having escaped southwards to Frankfort-on-the-Maine. Gœben, moving from Minden, had occupied Hanover late on the 17th of June, and Manteuffel, moving southwards after taking Stade, had marched some distance along the road towards Hanover.

The Hanoverians, as they moved the whole of their troops towards Göttingen, the point named for concentration, had broken up the railways south of Hanover, and had removed all the rolling stock to points south of the broken portions, so that none of it was available for the operations of the Prussians, who were endeavouring to march southwards as rapidly as they could. On the 20th of June the Hanoverian Army was concentrated at Göttingen; it was about 20,000 strong, divided into four brigades, placed under the command of Generals Knesebeck, De Vaux, Bülow, and Bothmer. They had with them some 1,700 or 1,800 cavalry, and about 42 guns, of which 22 were rifled. But they had no field organization of commissariat, they had no field hospital organization, they had no field transport organization, and those, I need scarcely say before such an audience as this, are not services which can be organized at four days' notice.

On the 20th of June we find the Hanoverian Army assembled at Göttingen. We find Beyer with his 20,000 troops, equal in number to the Hanoverians, at Cassel; we have Gœben with his 14,000 troops, except such portion as he has left in Hanover, two marches south of Hanover, on the road to Göttingen; and we have General Manteuffel still north of the capital with the bulk of his troops, though he has brought some of them down to Hanover.

Now, the problem for Hanover was, in the face of these troops assembling around her, what should be her course? She had reason to expect at this time that a Bavarian Army, which she knew had assembled to the number of about 40,000 on the river Maine, somewhere between Schweinfurt and Bamberg, would come to her assist-

ance. She also placed a certain amount of hope in the 8th Federal Corps, which was assembling at Frankfort-on-the-Maine. She trusted these would come to her aid, and she resolved to march down south to join them, relying on concentration with them as her best and only chance. Accordingly, her first plan was to move by Witzenhausen and Allendorf on Eschwege, and thence to Bebra or Eisenach, and so to join the Bavarians. It was intended that her troops should commence the march on the 21st, but on the 19th she received information that General Beyer was with his division at Cassel. Then she resolved that the march of her troops should be by way of Heiligenstadt; and thence in two columns by Wanfried and Mühlhausen on Eisenach.

On the 21st, the march of the Hanoverian troops commenced, and their head-quarters that evening were at Heiligenstadt. Then Hanover ascertained that General Beyer had pushed forward his troops, and had occupied some of the defiles of the river Werra; she heard, in fact, of troops being at Eschwege, for Beyer had put some infantry on waggons, and had sent them forward to occupy this place. She therefore decides that her march shall be no longer directed upon Wanfried, but that the whole Army shall move by Mühlhausen, and thence on Eisenach. Accordingly, on the 22nd her troops are again put in motion, and the head-quarters of her Army are brought to Mühlhausen.

In the meantime, General Falckenstein has decided that the division of Beyer, and his own division, shall be concentrated against the Hanoverians, whom he still believes to be at Göttingen. Marching south, the Hanoverians had left a rear guard north of Göttingen, and Falckenstein, coming down from Hanover, has encountered it, and believes it may be taken as an indication that the Hanoverian troops are about to defend Göttingen against him. Accordingly, he has ordered General Beyer to concentrate with him. Early on the 22nd Beyer had put his troops in motion, so that by night some of them are at Allendorf, some at Lichtenau, some at Münden, and some at Cassel. On this night of the 22nd, there is absolutely not one company to bar the march of the Hanoverians, if they should take the road by Gotha, because on the 21st the sole garrison of Gotha, two battalions of the troops of Saxe-Coburg-Gotha, had been moved, by order from Berlin, from Gotha to Eisenach. There were on this evening, in Eisenach, only these two battalions, each about 600 strong, and three weak battalions of Landwehr, which had been sent from the garrison of Erfurt. There is not a man, I repeat, in Gotha, or between Erfurt and Eisenach, which is thus feebly garrisoned, and the Hanoverian head-quarters are at Mühlhausen.

On the morning of the 23rd the Hanoverians, unaware of Beyer's movement to his left, again commenced their march. There is no doubt, from the official Hanoverian accounts, that the King of Hanover was most anxious, if it were possible, to effect his movement south without bloodshed; and fearing that, if he made a direct movement in the direction of Eisenach, he might be attacked in the defiles of the Hainich, and that his course might perhaps be stopped, and a battle

might ensue,—his troops also being badly provisioned, and the horses out of condition and exhausted, he decided to move by Langensalza, and thence to make his way southward through the Thuringian forest. On the 23rd, the Hanoverian Army moves, and, without encountering any enemy, reaches Langensalza, one of its four brigades being pushed out on the right flank to Behringen.

On the 21st, General Falckenstein had received information which placed it beyond doubt that the Hanoverians were not remaining in Göttingen, but were moving south on Mühlhausen. He therefore sends orders to Beyer to move on Eisenach, in order, if possible, to cut them off. The orders, however, do not reach Beyer's troops until they have completed their day's march on the 22nd, and they are not able to be put in motion again that day. On the 23rd they are still cantoned along the lower Werra, while Falckenstein, who has now reached Göttingen, halts his troops, Manteuffel being still in rear, and the Hanoverians in motion from Mühlhausen upon Langensalza.

We now hear of one of those remarkable incidents of warfare, which can only be understood, when we remember the proverb that "all is fair in love and in war." In the course of this day there arrived in the Hanoverian camp an officer from Gotha, where, as I have already told you, there was not a Prussian soldier, bearing a telegram from General von Möltke, at Berlin, to the effect that the Hanoverians were surrounded by the Prussians, and urging that they had better lay down their arms to save bloodshed. The King refused to consent to this request, but his troops were halted at Langensalza and at Behringen, and he sent an officer, one Major von Jacobi, to Gotha, to enter into negotiations with the King of Prussia at Berlin. The Prussian official account says, "From the moment that the Hanoverian "army commenced to enter into negotiations, its fate was decided." There is no doubt that it was so. From that moment we cease to see the steady pursuit of one single purpose, the march southward; we see only divided councils, partly the desire to march southwards, and partly the desire to save bloodshed by negotiations.

General Bülow's brigade has, on the night of the 23rd, its head-quarters at Behringen; the remainder of the Army is about Langensalza. In the evening, the troops of Saxe-Coburg-Gotha have been brought back from Eisenach to Gotha, and two battalions of Guards have arrived by rail from Berlin at Eisenach, so that there is now a small garrison both at Eisenach and at Gotha. During the night of the 23rd, information was received at the Hanoverian head-quarters, by which it appeared that they were certainly not surrounded so that it would be necessary for them to lay down their arms, but that Gotha, at all events, was only weakly garrisoned; so the King ordered an attack in force to be made on Gotha at five o'clock on the morning of the 24th. Very shortly after issuing that order, information reached him from the cavalry patrols to the effect that Eisenach was denuded of troops, because the battalions of Saxe-Coburg-Gotha had been moved back to Gotha, and the Guards had not yet arrived at Eisenach. Accordingly, orders were issued that the attack on Gotha should not be carried out, but that, while a demonstration was made there,

the real attack should be made in force upon Eisenach, with the view of breaking through, and so marching south. Before, however, these orders were carried out on the morning of the 24th, Major Jacobi returned from Gotha to the head-quarters at Langensalza, and informed the Commander-in-Chief of the Hanoverian Army, General von Arentsschildt, that he had received private information (I am taking this from the Hanoverian official account) placing it beyond doubt not only that Gotha is strongly garrisoned, but that the bulk of General Gœben's division has arrived there by rail from Hanover. At this time there were really only two weak battalions at Gotha. Major Jacobi also said he had every reason to believe that the proposition of which he had been the bearer from the King of Hanover, that the troops should be allowed a free passage south on condition of their not fighting for about two months, would be acceded to by the Prussians. The King, on receipt of this information, still anxious to save bloodshed, still anxious, if it were possible, to get to the south by peaceable means, countermands the order which he had issued for the attack to be made on Eisenach, and sends Major Jacobi back to Gotha. But a Staff Officer, Colonel Rudorff, who had accompanied the column of Bülow, and General Bülow, were so convinced of the immense importance of occupying Eisenach, whether the negotiations should come to a successful end or not, that they decided upon advancing upon the town, and summoning the officer in command to surrender, though resolving that they will not actually proceed to the assault until they have received further orders from head-quarters. On the morning of the 24th Bülow's brigade advances from Behringen upon Eisenach. About nine o'clock he summons Colonel von Osten Sacken, who is commanding the two regiments of Guards there, to surrender. He refuses to do so, and Bülow gives him until three o'clock in the afternoon either to surrender, or to remove the inhabitants, other than soldiers, out of Eisenach. Word is sent back to head-quarters of what has been done, and the King is now so completely convinced of the falsity of General von Möltke's telegram, that he orders the other brigades to follow Bülow, and sends word to that commander to continue the attack, but to give half an hour's more law to the Colonel commanding at Eisenach.

On that half hour hung the fate of the Hanoverian Army. Bülow has summoned Colonel von Osten Sacken to the final surrender. He has placed his infantry in position to attack Eisenach; he has got his guns in battery; when there comes to him a telegram from Major Jacobi to the effect that the Hanoverian terms have been agreed to, and that hostilities should therefore be avoided. Bülow holds a council of war, and they decide that, in the face of this, he cannot attack Eisenach. Accordingly, he agrees to a truce till eight a.m. of the 25th, to be terminable at three hours' notice.

How did this happen? The King had resolved to break off the negotiations, and Major Jacobi had been ordered back from Gotha to Langensalza, having been confidentially informed of Bülow's intended attack upon Eisenach; but Major Jacobi remained at Gotha after receiving those orders. A telegram meanwhile arrives from Count

Bismarck, saying that certain terms have been agreed to. But these terms appear not to have been those which the King of Hanover had offered. It appears that suggestions had been made to Berlin, but not by the King of Hanover, that the Hanoverian Army should be allowed to march southward, on the condition of its not fighting against Prussia for one year. Those terms, which had not been offered by Hanover, were the terms which were said to be accepted, and it being stated that a Prussian General Officer was on the road from Berlin to complete negotiations with the King of Hanover, Major Jacobi had been induced to send this telegram to Bülow, which prevented, as the Prussians themselves say in their official account, the capture of Eisenach; and which thus was the final cause that prevented the Hanoverian Army from escaping to the south. When General von Arentsschildt rides up from Langensalza to Eisenach, and expects to find that city in Bülow's hands, he finds there instead Jacobi's telegram. It is now evening; after three hours' notice it would be too late for an attack to be made on Eisenach, and accordingly no operations could be carried on till the following morning. But before the following morning Falckenstein, recognising the enormous importance of reinforcing Eisenach, has hurried up a detachment of Gœben's troops by the railway, which is now repaired from Göttingen as far as Münden, and again from Cassel to Eisenach. Beyer has now brought numbers of his troops southward along the Werra. A detachment, under command of General Flies, has been sent round from Manteuffel's division by rail far away to the east, by Magdeburg, through Erfurt, towards Gotha. Troops, under the command of General Seckendorf, which had been sent to intercept the Hanoverians, in case of their marching in a north-easterly direction, have also been sent round towards Gotha.

Yet still on the morning of the 25th there was no force which could have withstood the attack of the Hanoverians. But the reinforcements were exaggerated in the Hanoverian camp; and the King resolved to await the arrival of the Prussian envoy from Berlin, in hopes of successful negotiations. He came. His terms were such as the King would not accept; but a short truce was arranged, Prussia wanting time to surround the Hanoverians, Hanover wanting time to receive aid from Bavaria. The day was thus lost to the Hanoverians, but not so to Prussia.

Beyer's troops have reached Kreuzburg and Treffurt; some of them have gained Eisenach. The bulk of Gœben's division is at Eisenach. Flies and Seckendorf, and more troops from Erfurt, have reached Gotha, and so that night there were about 8,000 men at Kreuzburg, 12,000 men in Eisenach, and 8,000 in Gotha; whereas, on the two preceding days there was scarcely a man to oppose the Hanoverian march.

And now General von Falckenstein himself has arrived on the scene at Eisenach. He has refused to let a Hanoverian envoy proceed to Berlin: he says he does not recognise the truce which has been made by General von Alvensleben, the officer from Berlin, and he impresses the belief so strongly on the Hanoverian envoy that Bülow's troops were to be attacked in front of Eisenach, that they were drawn back to

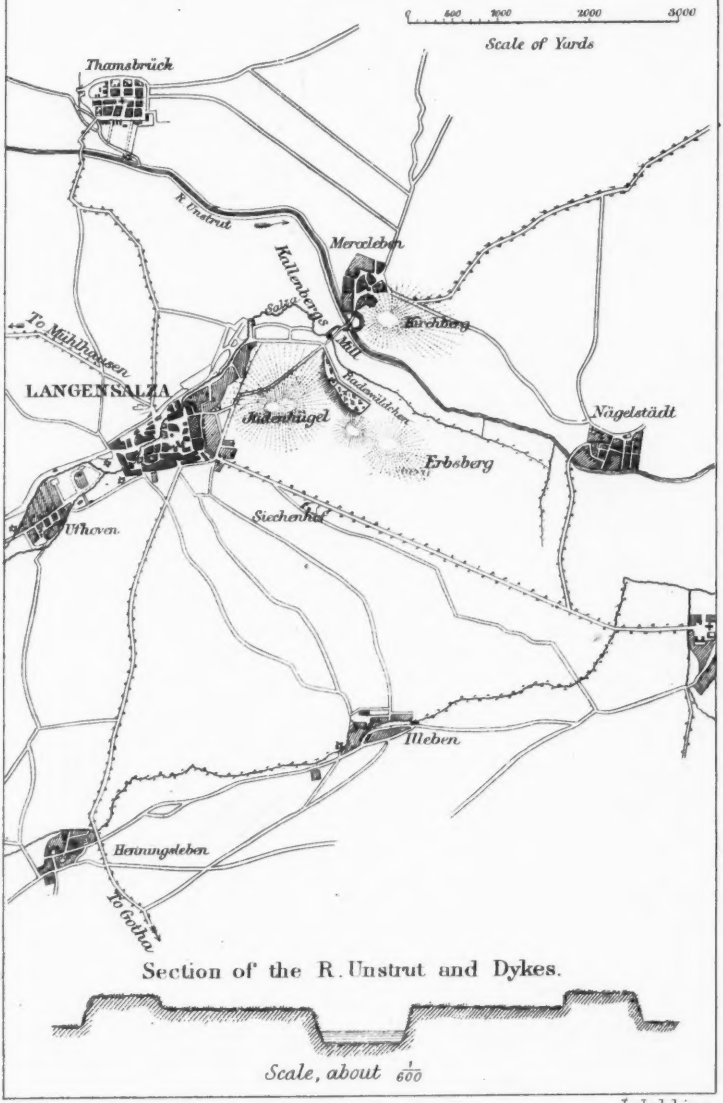
Behringen. On the 26th the truce is recognised by Falckenstein, but a Prussian envoy arrives at the Hanoverian Camp, and says that he has received orders that unless the terms which Prussia offers are accepted, (practically the same terms which had been offered before the declaration of war, and which the King had refused and now again refuses to accept,) the Prussians will immediately attack the Hanoverians. Then on the 26th the Hanoverian troops are retired behind the river Unstrut, taking up a defensive position between the villages of Thamsbrück, Merxleben, and Nägelstädt, so as to be ready to receive the expected attack either from the direction of Gotha, of Eisenach, or of Mühlhausen. They retire there on the night of the 26th, having expected throughout the day to receive an attack from the troops of General Flies, which had advanced from Gotha as far as Warza; but on the 26th they receive no attack, and it is not till the 27th that the battle of Langensalza takes place.

It so happens that although there were 12,000 troops at Eisenach and 8,000 at Gotha, only the 8,000 at Gotha attacked the Hanoverians on the 27th. The authorities at Berlin (this I take again from the Prussian official account) had received information on the 26th that the Hanoverian Army was retreating in a north-easterly direction. This was probably due to its movement of retiring from Behringen on Langensalza and behind the river Unstrut. They accordingly telegraphed to General von Falckenstein at Eisenach, and to General Flies at Gotha, that they were to put themselves on the traces of the Hanoverians. At the same time General Falckenstein had reason to believe that the Bavarians were commencing to make a northward march; he therefore sent a detachment of his force as far south as Vacha, and kept the bulk of Gœben's and Beyer's troops about Eisenach; but he sent large reinforcements to Manteuffel at Göttingen, who was ordered to move on Mühlhausen and cut off the retreat of the Hanoverians, at the same time that General Flies was to continue on their traces.

It resulted from this, that on the morning of the 27th only Flies with his 8,000 troops advanced against the Hanoverians. Advancing in the early morning, the 8,000 infantry of Flies, of which about a third were landwehr, with 22 guns, of which six were rifled, and only three small squadrons of garrison or landwehr cavalry, encountered the Hanoverian outposts towards half-past eight o'clock, and very soon drove them in through Henningsleben and through Langensalza, till they had reached the purely defensive position taken up by their army behind the river Unstrut.

Before I proceed to say anything about the actual facts of this battle, I would wish to remark that it has been made so much a theme of controversy, and has been so often used as a proof that the Prussian system of tactics is bad, in consequence of the way in which the Prussians certainly failed in this battle, that I think it may be desirable for me to state very briefly what appears to be the true Prussian system, that is to say, the true perpendicular order of attack of which we have heard so much; and then we shall see, as we examine the facts, how far the real spirit of that perpendicular order of attack was adhered to,

BATTLE FIELD OF LANGENSALZA.
27 June 1866.



Section of the R. Unstrut and Dykes.

Scale, about $\frac{1}{600}$

J. Jobbins

and how far it was departed from, in almost every particular by the General in command of the Prussian troops.*

The perpendicular order of attack appears to me to be in its true spirit this: that an advanced guard goes to the front, reconnoitres, spreads out, feels the enemy, ascertains which are really the weak points, and on the principle of engaging as few troops as possible, and getting as much out of them as possible, very often engages in a very severe attack, and very often bears the brunt of the battle. In fact, we know the French critics say that one great fault of the Prussian perpendicular order of attack is that too much is required from the advanced guard. The main body follows, not necessarily so near as to be involved in the attack of the advanced guard, but so near that when the advanced guard has found the weak points, it may attack with its fresh unbroken masses upon the point selected; or following out (and this, I believe, was very frequently done during the late Prussian manœuvres) the system of flank attack, while the advanced guard continues its front attack, the main body moves round to the flank and endeavours to outflank the enemy, so that the attack of the advanced guard becomes a feint. Then comes the reserve. The troops of the reserve should be held in hand by the Commanding General, so that they may be used, if necessary, to complete the decisive shock at the right moment or to cover the retreat. The Prussians recognise that there must be occasions on which troops must be detached from the reserve to cover the flanks, or for some other purpose; but I believe they recognise that every such detachment from the reserve is an evil, and is to be avoided, if it be possible.

Now, General Flies on this occasion was about to attack with 8,000 troops some 20,000 Hanoverians, in order to hold them in position, and prevent their escaping northwards. He must have known that it was almost impossible for him to gain a victory, and that he was extremely likely to have to experience a retreat. It would occur to most soldiers that, under those circumstances, the point of the greatest importance would be to hold in hand a reserve ready to cover that retreat.

Let us examine the actual events of the battle. By nine or ten o'clock the Hanoverian outposts having been driven in and across the river Unstrut (of course it will be impossible for me in the time at my disposal to go into all the details of this battle), the advanced guard of the Prussians is sent forward. It is a very small advanced guard, comprising only the eight companies of the two battalions of the troops of Saxe-Coburg-Gotha, a squadron of landwehr cavalry, and a battery. Four companies of it occupy Langensalza, four companies more, occupy the hill known as the Jüdenhügel. The advanced guard does not spread out to any considerable extent, it does not to any extent reconnoitre the position. Meanwhile the main body has been deployed behind the Jüdenhügel, while the reserve has been deployed near the Siechenhof, and so little are the true duties of the advanced

* I have partially availed myself here of the valuable criticisms of the anonymous author of "Tacktische Rückblicke;" and I have derived great assistance in analysing this battle from some notes with which I have been favoured by Major Colley, 2nd Queen's Royal Regiment.

guard performed, that we find the first troops to advance against Merxleben, which is the key of the position, are companies of the main body, followed by troops of the advanced guard.

I must here say something about the battle-field. The river Unstrut has been artificially straightened and embanked in its course from Thamsbrück to a point some hundreds of yards below Merxleben. There were at this time some four or five feet of water in the river, which has steep and high banks. There is then a flat space of meadow land from 40 to 50 feet on each side, and then a bank of about four feet high, so that each of these dykes forms a parapet. You have, in fact, a double line, and troops standing behind either embankment can make it almost impossible for troops to cross from the other side. This obstacle had a very great effect upon the battle. At Merxleben itself the river has two courses. There is the old curved course of the river through which the water continues to flow, while the new course of the river is almost entirely empty. There is a bridge over each, and a causeway between. Then there is a long raised causeway south of the bridge over the new channel running for about 200 or 250 yards beside the Salza, so that it is almost impossible for troops, in the face of a heavy fire, to pass such a defile as this. Yet the only places by which the Unstrut could be crossed, except through the water, were this immensely difficult defile at Merxleben, or the bridges at Nägelstädt or at Thamsbrück.

Now, the Hanoverian troops were posted, one brigade at Merxleben, one near Thamsbrück, one near Nägelstädt, and one in reserve behind Merxleben. As Flies' attack gradually developed itself against their position, the brigade Bothmer from Nägelstädt was drawn in to its right; the brigade Bülow, from Thamsbrück, was drawn in to its left, and the greater portion of the reserve artillery, and the artillery of De Vaux's brigade, was placed on the hill known as the Kirchberg, to reply to the Prussian artillery, most of which was posted on the Jüdenhügel. We find that, by one o'clock, while the Hanoverian troops are acting purely on the defensive behind the Unstrut, General Flies has sent three companies, one from his main body, followed by two from his advanced guard, with half a squadron of cavalry, to occupy the village of Thamsbrück, more than a mile and a half away from the main body, in order to prevent his left being turned. He has advanced a portion of his skirmishers along the Salza, a stream which flows into the Unstrut opposite Merxleben. But they have been unable to make any way beyond the Salza, because the flat meadows between it and the Unstrut are swept by the fire of the Hanoverian skirmishers, and also by a battery of Bülow's brigade, which has taken up its position to the north-west of Merxleben. Flies has occupied Kallenberg's Mill with two companies of his main body, and the greater portion of his main body is thrown into the wood known as Badewäldchen (Bath Woods), and into the buildings of the adjoining bathing establishment, where patients resort to be cured by mineral springs. It appears evident to me that the troops made their way of their own accord into these Bath Woods, as being the only place where they could obtain cover at all within reach of the Hanoverian position.

The skirmishers have been pushed on, and they line the dry ditch which runs in front of the Badewäldchen; a few of them have run along under the shelter of the causeway by the mill, and have lined the bank of the Unstrut on the near side. But they have been unable to make any sustained effort to cross the Unstrut. The only effort that was made was by the rush of one company, which tried to storm the barricaded bridges and cross at Merxleben, and which failed signally. There was no such sustained attack by the main body as, it appears, should be the object of a main body, if it engage at all seriously with the enemy.

We now come to this still more important point, that the reserves have been all sent to the extreme right of the line, to occupy the spur known as the Erbsberg, because it was evident that the brigade of General Bothmer was about to attempt the passage of the river opposite to that point. Thus, although a mass of troops from the main body is crowded uselessly in the Badewäldchen, the reserve is taken to oppose this flank attack on the right of the line. The result was that no reserve was left at one o'clock in the day, although as yet the Hanoverians had not a man across the river.

At one o'clock it appeared to General von Arentsschildt that it was time for him to pass from the defensive to an offensive movement; and now this river Unstrut, which has hitherto been so difficult an obstacle to his enemies, becomes just as difficult an obstacle to himself. He gives orders to Bülow's brigade on the right, to De Vaux's brigade in the centre, and to Bothmer's brigade on the left, to attempt the passage of the river. General Bothmer's brigade, opposite the Erbsberg, rushes down to the river, and attempts to cross it. The men are armed with the old muzzle-loading rifles, and have paper cartridges, and the river is four or five feet deep. In crossing the river, the first troops get their ammunition wet, and when they get across, are unable to use their rifles. Almost decimated by the fire of the Prussians, they are obliged to retreat. A second battalion attempts the passage. They hold their ammunition above their heads; but they get the water into the barrels of their rifles, and they are almost as helpless as the others. At half-past one General Bothmer is obliged to abandon the attempt to make the passage at this point; the natural obstacle and the fire of the enemy are too heavy for him. But the brigade Bülow, on the right, succeeds in making its passage. It crosses the river, which is not so difficult at this point; it presses on and drives back the Prussians out of the buildings before Langensalza, storming them in succession, with very heavy loss; it drives the enemy back on the Salza; it enters the town of Langensalza; and its troops take in flank the guns of the Prussians on the crest of the Jüdenhügel. These guns are outflanked, and the only escort they have, being three small companies from the advanced guard, they are of course obliged to retire. The Prussian defenders of Kallenberg's Mill are at this time driven out by the guns on the Kirchberg; they make a rush across the road, but being outflanked by the Hanoverian Guards, who have crossed the Unstrut just above Merxleben, and reached the Salza, while some of them succeed in

crossing the road and entering the Badewäldchen, some of them run back into the mill, and are taken prisoners. But a portion of them suceeed in making their way into this already overcrowded wood, upon which the Hanoverian guns on the Kirchberg are now able to direct their whole fire, the guns on the Jüdenhügel having retired.

Before this time General Flies appears to have given orders that the reserve troops, which had been placed on the right under the command of General Seckendorf, should retire from their position on the Erbsberg, and they have already retreated and joined the troops from the Jüdenhügel, south of Langensalza. Yet, at four o'clock in the afternoon, no order to retire has reached the troops that are left in the Badewäldchen, who are now completely outflanked by infantry on their left, while some of the reserve cavalry have pushed on across the Merxleben defile, though not without considerable difficulty and delay, caused by their becoming jammed at the bridges. And now only the order reaches these troops in the Badewäldchen to retire, while the Hanoverians are pressing on against them in front and flank.

The retreat having fairly commenced, the infantry of the Hanoverians cease to have much power, and the pursuit, as I suppose will always be the case, is entrusted to cavalry. And now occurred that remarkably interesting series of cavalry charges which have formed the text for so many comments. But I should first say that comparatively early in the day the regiment of Duke of Cambridge Dragoons, which had been attached to the brigade in the centre, had moved round across the bridge at Nägelstädt, and having watered and fed the horses, had actually got into the rear of the Prussian troops. There is some little discrepancy in the accounts of the Prussians and of the Hanoverians as to the charge which first took place on the artillery. The Prussians say that a rifled battery of theirs was in position close by the Siechenhof; that this regiment of dragoons appeared on the point of charging the battery, but that the battery fired into the dragoons, and that they retired, losing a captain in the charge. The Hanoverians do not mention any such charge as that, but they do mention losing a captain in a charge (which, according to the Prussians, was their second charge), upon two guns which had retired with Seckendorf's reserve from the Erbsberg and were moving towards the south-west. Through these guns the Hanoverian cavalry rode, and the guns were captured, and not retaken by the Prussians. The Prussians say that these two guns were taken because their horses took fright during the charge, and fell into a ravine. Be that as it may, for it is almost impossible to decide disputed questions of this nature, at all events those two guns were captured by the Duke of Cambridge Dragoons, and remained as trophies in the hands of the Hanoverians.

Now, as the troops are pouring out from the Badewäldchen, some of the Hanoverian reserve cavalry have moved across the eastern slope of the Jüdenhügel, and are capturing numbers of Prussians as they run in broken order and confusion out of the wood. But the greater portion of these troops in the Badewäldchen succeed in forming themselves into two masses, composed of men of almost every regiment

that had been engaged in the action; and these two bodies retreat with the view of joining the rest south of Langensalza, on the Gotha road. The Duke of Cambridge Dragoons appear on their left flank as they move in this direction, and they form two squares, about 700 paces apart, on the upper and middle Illeben roads. The Hanoverian Life Guards had moved past the Jüdenhügel down towards the north of these squares, and charge the western square. Two squadrons charge in line upon the north face of the western square, of which less than half the men were armed with breech-loaders. Then happened, what Sir Shaw Kennedy tells us occurred over and over again at Waterloo, that which Marshal Marmont says is likely always to happen, the cavalry did not ride straight at the square, they open out to the right and the left, and passing by the flank of the squares they receive two withering volleys, which brought to the ground two of their officers, a twelfth of their men, and a fifth of their horses. The regiment retires to reform, and this column passes on to rejoin the rest of the retiring Prussians unmolested further.

But the eastern square was not so fortunate. There is great difficulty in ascertaining what occurred in one particular here. The Prussians say that the Colonel in command of this square mistook the Duke of Cambridge Dragoons for Prussian cavalry, and rode out to them. The Hanoverians say that the Colonel rode out and offered to surrender this square, but that when he heard the firing of the western square he changed his mind and rode back to his command. But this certainly happened: when he rode back his square was charged at the same time on the north and west faces by two squadrons of the cuirassiers of the Hanoverian Guard; one of them riding at the north face, and the other squadron coming down in the same direction, and then wheeling to attack the west face. Again, what was the result? The squadron advancing towards the north flank of the square meets such a fearful fire, (this square had nearly all breech-loaders,) that four officers are shot down, and the squadron passes off to right and to left; that portion which passes off to the right rides into the other squadron which is wheeling to attack the west face of the square, so that the charge on the west face did not come off. The square in this way has for the moment been successful. But almost at the next moment, (there is no doubt there was the keenest rivalry between these troops, that the one regiment of cavalry was trying how it could possibly outvie the other in deeds of gallantry,) at that moment there comes down on the south flank of the square a charge from the second squadron of the Duke of Cambridge Dragoons, and they ride straight as a line at and into the square. In that charge every officer of the squadron fell and one-third of the men. They ride into the square, they penetrate it; but I believe there is a great difference between a square being penetrated and being broken. There is no doubt that the square was not broken by this charge, and that it remained on the ground. No sooner has it partially recovered from this shock which it has received, while the squadron has retired to re-form, than it receives another charge from the cuirassiers of the Guard, whom it has once repulsed, but who will not be outdone by the Duke of Cambridge Dragoons, and who again

resolve to attack, though with only three officers left. Again they charge the north face, and several of them penetrate into the square. A standard-bearer of that regiment fought his way out of the square after his horse was killed, carrying out his standard; and I believe other troopers did the same. Yet I believe, although it is very difficult to ascertain the exact truth of these accounts, that the square was not permanently broken. The Prussians say they re-formed immediately with the utmost coolness; and there is no doubt, from the Hanoverian account, that they were not permanently dispersed; for it speaks of two guns of Horse Artillery having now at last succeeded in getting over the ditches by which they had been delayed, and firing at 900 paces upon this square which was now retreating westward. At the same time the Hanoverians say they captured large numbers of prisoners, whom they call remnants of this square.

That was the last scene of this battle. The Prussians, covered by their artillery, drew off in the direction of Henningsleben. The young Hanoverian officers were eager to pursue, but it was almost impossible. The horses were utterly exhausted, while many of the men had had no food that day, for the action had begun before they cooked; and it was one of those hot, sultry days in which every movement made by the troops was a burden to them. The Prussians tell us that they lost scores of men, who fainted under the heat, before they reached the Badewäldchen. The Hanoverians had lost in the action no less than 32 Officers and 342 men killed, and 70 Officers and 981 men wounded. In De Vaux's brigade the infantry lost 24 Officers and 492 men; and the Duke of Cambridge Dragoons, out of a total strength of 276, lost 5 Officers and 51 men. The Prussian losses are stated officially to be 41 Officers and 805 men killed and wounded; and the Hanoverians say that they took prisoners 10 Officers and 897 men.

That night the King of Hanover applied for a truce to bury the dead; it was refused by the Prussian General. The Hanoverians threatened to attack Gotha, and again offer to treat on the condition of free passage to the South, not bearing arms against Prussia for two months. Flies said he must telegraph to Berlin. By 9 A.M., on the 28th, the answer was returned. Berlin refused to negotiate at all. Von Möltke telegraphed to Falckenstein to concentrate every man, and force the Hanoverians to surrender. Gœben had moved on Gotha. Beyer arrived in the course of the day. Manteuffel had drawn his forces round the ill-fated army to the north and north-east, and by nightfall of the 28th, they were indeed surrounded by more than 40,000 troops.

During the day there had occurred in the Hanoverian camp one of those events, whose intensity, they who lead calm lives can scarcely appreciate. A council of war was held, and it was declared by the Commander-in-Chief and the Generals of the Hanoverians, on their honour as soldiers, that it was impossible for the army to make a further stand. The Hanoverians had no provisions, no commissariat, no ammunition; both men and horses were weary and exhausted; and they said, therefore, that it was better for the King to seek for a capitulation, in order to save further and unnecessary bloodshed. Then there was issued that document,

that one knows not how to read without emotion, in which the King, already so heavily stricken in his blindness, relates to his soldiers this statement of his Generals, and says, that though it has pleased Providence to lay a heavy affliction upon himself, his house, and his army, yet he can look back with pride to this day as worthy of the old memories of his race, and will leave the future in the hands of an Almighty and a merciful God.

The next day the capitulation was signed. The Hanoverian troops were sent back to their homes, bound not to serve against Prussia. The Hanoverian Army was "got rid of." Twenty thousand men were struck off the roll of Prussia's enemies. Falckenstein was free to turn to the south against his other foes; and Hanover, as an independent kingdom, was wiped out of the map of Europe.

Your Royal Highness, it only remains for me to thank you for the great honour you have done me in presiding here to day, and to say to my audience, among whom I see many who will look at this subject from other than the strategical and tactical points of view, that I hope they will carry away, at all events, this one lesson,—an old lesson re-taught by the last campaign of Hanover,—that you cannot arm and recruit in the moment of emergency; and that a nation which in time of peace enters upon the career of reducing its trained forces, above all its special arms, its cavalry and its artillery, may have to pay in bitter humiliation, and in the life-blood of the bravest of its sons, a price, compared with which in that moment, the very last coin in its exchequer would weigh but as a feather in the balance.

The Duke of CAMBRIDGE: I am sure that I express the sentiments of every one present when I say, that we have been extremely gratified by the very able lecture which you, Captain Brackenbury, have given us on this interesting subject. It is a subject, the contemplation of which at one moment affords me great pleasure, and at another, still greater pain. I would notice with high satisfaction the fact, that the regiment which bore my name took so conspicuous a part in the momentous battle of Langensalza. I have known the regiment personally, and as one which the late Duke my father commanded. And here I wish to make a few remarks upon the subject of that cavalry charge. I think the subject a very important one. It has always been supposed that young troops are the only troops that will perform such a feat of gallantry, because they are not aware of their danger. It so happens that the great portion of the Hanoverian Army,—certainly the cavalry and artillery,—are recruited as our Army is, by volunteers and not by conscripts. Now, the fact of these men having done what they did, is strong evidence that conscripts alone are not the description of force which is most to be trusted on these critical occasions. I hope it may be a lesson to us. And I hope also that the observations which you have made, with reference to "being prepared for war," may be a lesson to us, a lesson which at this grave moment ought to be well weighed, when we see the feeling in favour of economy, which very naturally exists, but which ought also to be considered in relation to the many momentous interests which are at stake on the other side. I would make one more remark. It is that, without wishing to criticize

the proceedings of this campaign,—which, to a certain extent, was a very unfortunate one—what has occurred on many other occasions, appears to me to have occurred on this occasion. I had always understood before, and the lecture you have given only confirms me in that belief, that if the object which the Hanoverian Army had in view when they started, had been consistently and perseveringly followed up, and no attempt had been made to delay the movement,—which unfortunately was the cause of what afterwards occurred,—probably the Hanoverian Army would have been enabled to have passed through that line, not only without having had to lay down its arms,—which it had to do at the end of the campaign, but without that bloodshed which the King of Hanover and his Generals naturally wished to prevent.

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